Water sustainable management for buildings

Manejo sustentable del agua en los edificios

Silverio Hernández-Moreno*, Jesús Enrique de Hoyos-Martínez*, Juan Arturo Ocaña-Ponce*

ABSTRACT

This paper presents a literature review article that deals with how to manage water in buildings, specifically in facility projects, in ways to save water during the use, maintenance and operation of the building. This work is aimed at architects, builders and developers, and may be helpful for decision-making in the planning and management of efficient water use in buildings.

RESUMEN

Este trabajo es un artículo de revisión relacionado con el manejo y gestión del recurso agua, particularmente en proyectos de edificaciones, con el fin de propiciar ahorro de agua durante el uso, mantenimiento y operación del inmueble. Este documento está dirigido a arquitectos, constructores y desarrolladores inmobiliarios y puede ser de gran utilidad para la toma de decisiones en la fase de planeación y de gestión del uso eficiente del agua en los edificios.

INTRODUCTION

The main objective when managing water in buildings is a reduction in consumption using different techniques and criteria for the building itself and plumbing accessories. The sustainable use of water is a measure that must be implemented, not only as a fad, but as a requirement for the use of natural, economic and human resources today and in the future [1]. This will allow access for more users, reduce the processes and the cost for water treatment and transportation, increase energy savings, protect the environment and help replenish groundwater. Sustainable management of water in buildings will also help improve public finance aid in the sustainable regional and global development [2]. In Mexico, it is necessary to develop and pass new regulations which make implementation possible and obligate construction companies and citizens in general to save and manage water in a sustainable fashion. In this way, it is possible to protect this natural resource, which is possibly the most important natural resource of the planet.

Water management and control techniques can be implemented by builders, architects, engineers and construction companies, who are (for the most part and together with the authorities) responsible for the use of the nation's resources.

Recibido: 7 de septiembre de 2012
Aceptado: 23 de noviembre de 2012

Keywords:
Water; sustainability; buildings.

Palabras clave:
Agua; sustentabilidad; edificios.

° Strategies of sustainable design for the saving and control of water consumption in buildings

These strategies, which can be implemented within projects and designs, are described in [3]:

- Reduction of water loss due to the building itself and its maintenance.

* Facultad de Arquitectura y Diseño. Universidad Autónoma del Estado de México. Cerro de Coatepec, Ciudad Universitaria, C. P. 50110. Toluca, México. Teléfonos: (01 722) 2-14-04-14, 2-14-04-66 y 2-15-48-52; fax: 2 14-05-23. Correo electrónico: silverhm2002@yahoo.com.mx

- General reduction of consumption from fixtures and accessories inside the building (for example, changing sinks, toilets, showers, etcetera).

- Searching for alternate sources of water (for example, catching rainwater from roofs).

- The responsible use of water during and after -for example- applications for greywater and run-off. This will be determined directly according to the type of building and each one will be responsible for the use and recycling of water in water way possible [4]. Wherever this is applied, the cost of water should be adjusted according to its use. For example, for industrial activities the quantities of water are very large and there is generally no solid basis for its price nor does industry have any obligation to recover at least a percentage of the total water used and contaminated. The water is often contaminated in a way that recycling and treatment is impossible, so the charge should be much higher for this type of use.

- Another resource that can be implemented to protect water is to create incentives to families or companies to install treatment plants, recycle water, reuse water and, in general, reduce its consumption in their buildings. Incentives could be a tax reduction, better supply, etcetera.

The rationing and sustainable management of water also includes the creation of programs and special projects which attend to primary needs where any of the following have been identified: contamination, waste, lack of supply, misuse of this precious liquid, etcetera [5].

In new construction, it is easier to establish strategies and recommendations which help save water in the building. When it comes to remodeling and repairs, it is important to know that implementing sustainability techniques are more difficult. It is possible, though; people involved have the obligation to upgrade their buildings to respond to these new needs and requirements (which change over time). It is necessary to reduce the consumption to a minimum in several ways, such as reducing the use of hot water and proposing systems of water harvesting, etcetera. All of this helps to reduce the negative impact on the environment and save on the energy used for the cycle of water life in buildings. It can also help improve economic savings and comfort for the user [6].

Figure 1. Harvesting rainwater, a recommendation for the sustainable management and best use of water in buildings (source: Center for Maximum Potential Building Systems, Texas Guide for Rainwater Harvesting, TWDB, Texas Center, Texas, 1995).

Within the design for a system of water harvesting in Mexican homes, it has been calculated that a 5 member family would need 37,5 m^3 of water for the dry months. This information was calculated based on the minimum needs for food preparation, drinking and personal care [10]. The dry months vary depending upon the location, weather and humidity. On average, there are 4 to 5 dry months when a system of rain harvesting could provide for basic needs.

A general plan that interested persons should follow for the sustainable management of water in buildings are the 8 steps from the **Water Management Plan**[1] for buildings:

1. Compile information. The process should start with the compiling of information necessary to understand the consumption required; the priorities are: architectural plan, number of users and visitors, maintenance programs and operation of systems within the building. A list should be made of the main equipment and accessories that can satisfy the services, as well as the technical information from the manufacturer of these systems and accessories. Exterior water consumption must also be calculated. The price of water for that zone for the two months before the study and a review of the municipal network would be useful.

2. In the case of complex buildings, water supply experts are needed to determine the requirements which will influence the design later on. The architect should coordinate with others in a way that achieves a complete design, including the

[1] Center for Maximum Potential Building Systems, Texas Guide for Rainwater Harvesting, TWDB, Texas Center, Texas, 1995.

other design elements, as well as the management of energy, interior quality and comfort of the building, materials and site management. This design should determine and foresee circumstances which can be exploited for a better, more complete design.

3. Propose and evaluate various options for water management. With the information compiled, several feasible proposals should be created in order to improve water supply and save on costs in different parts of the building (*i.e.*, estimating the per day costs of each proposal and applying that proposal to the complete design of the building) [6].

4. Evaluate the cost of the complete life cycle for each proposal or option in the management of water. Each option or proposal requires an economic study to determine the most viable proposal. The most viable proposal should technically be the one which reduces water consumption the most and saves more electrical energy and chemical products like gas, etcetera. Within these proposals or design options, it also can be included passive systems which diminish the consumption of water and energy simultaneously. These options could be: cooling towers, water saving toilets, dry urinals, water tanks and tanks for the harvesting of rain water, gutters for rain harvesting, etcetera. The best option should be determined for reducing the consumption of water as much as possible, with passives systems or automated systems (an example of automated systems is using sensors on faucets to avoid wasting water).

5. Develop a water management plan for the post-construction phase as well as an internal education program for personnel and user to help in the management and administration of the building by producing operation and best use manuals for city, rain, treated, recycled and reused water [7].

6. Inform the user and administrator of the building about the programs designed to manage water in the building, in order to the water saving actions can be executed. Explain in detail the benefits of respecting the sustainable water management plan and the plan for the rest of the resources used in the building.

7. Implement and execute the water management plan for the building. During the entire life cycle of the building, it is necessary to implement the original plans for water management, starting with the preliminary design, then with the development of that design, the construction of the building, the occupation stage, maintenance and –possibly- remodeling and up until the end of its useful life [6].

8. Control and supervise the program and water management plan in the building. Supervise and watch that the operability and maintenance recommendations are complied with, reviewing and evaluating the objectives reached -mainly in water consumption savings. To do this, it is necessary to establish contact with those responsible for maintenance and operations in the building to ensure that the general sustainability plan is being respected (including the water management program).

Table 1 shows examples of how the implementation of accessories in buildings can help save water in a considerable manner.

Table 1.
Savings in water consumption in buildings with urinals of different types

Type of building	Number of users	Number of urinals	Number of uses each day	Hydraulic rams used	Days of the year	Water use (L) per year only in urinals
Small office without water management:	25	1	3	3	260	2 200 000
Small office with water management:	25	1	3	1	260	73 800
Restaurant without water management:	150	3	1	3	360	204 000
Restaurant with water management:	150	3	1	1	360	68 100
School without water management:	300	10	2	3	185	126 000
School with water management:	300	10	2	1	185	42 000

Source: Center for Maximum Potential Building Systems, *Water Saving in Buildings*, TWDB, Texas Center, Texas, 1995.

Minimizing the use of domestic water

It is very important to know how it is possible to reduce the consumption of domestic water, since homes are what are built the most. Through the appropriate selection of fixtures and accessories for bathrooms, kitchens, gardens, etcetera, it is possible to minimize the use of this precious liquid in any kind of building, without reducing the quality of the water supply (chemically, physically or in time and speed).

The following technical design recommendations can help achieve better use of water, as well as the sustainable management of this precious liquid.

- Adequate selection of accessories and fixtures. Adequate plumbing should be selected for the building, as well as accessories with low consumption capable of supplying the water in a normal fashion -when it comes to quality and time. The low consumption includes both the liquid and the energy used [7]. Special attention should be made to kitchen and bathroom fixtures. The following points are critical for saving water in homes:

- water pressure in sinks;

- toilets and urinals with low consumption and good supply;

- management of general plumbing for better water pressure;

- automatic controls in sinks and toilets;

- faucets which regulate water flow and pressure;

- appliances for washing clothes and dishes with low water and energy consumption;

- water re-use and recycling;

- harvesting rainwater;

- showers with better water pressure and low consumption.

- Control of ozone emissions. Ozone emissions from laundry appliances should be considered and controlled, especially in buildings where the demand for clean laundry is high like in hospitals and Laundromats. Water condensers can control these emissions within the service system of the buildings [6]. Activated oxygen with electric currents can be used instead of detergents, chlorine and hot water. This does not only saves water, but protects groundwater supplies from contamination. Money can be saved by not buying bleach and detergents (which are also unhealthy), as well as in the energy that used to heat the water for washing.

- The use of faucets and sinks with better water pressure also save water. Consider that to save water with one of these systems, it is necessary to change a faucet with 18,927059 L of pressure for one with 6,05665888 L of pressure and a toilet tank of 15 L for one of 6 L approximately. It is even better if regular toilets can be changed for dry toilets with passive techniques and economical apparatus to help with the sustainable management of water and all of our resources [6].

° Water quality and its possible re-use

All building projects should propose and ensure a high level of water quality. This includes quality drinking water with the proper chemical and physical properties.

Some recommendations for water quality are:

- Standards. Specify in the project the criteria for the building itself and the way water will be administered in the building, including sustainability criteria. All the water should be drinkable and healthy.

- Take care that the areas of the building are adequate for the quantity of water that will be supplied, based on the current health department regulations. Be careful that the water coming from the city network complies with quality standards.

- Test the quality of the water to ensure its use in our buildings and to propose systems that help us especially in those buildings. The design and planning for the management of this resource also involves aspects of public health, which is why it is important to test the water in certified laboratories.

- Filtration apparatus for human use. It is recommendable because the municipal water is not drinkable for human ingestion; it is necessary to filter it to prepare food and to drink. Apart from boiling it, filtration helps save on bottled water and on energy expenses for users and owners. Boiling or filtration helps reduce the environmental impact caused by the transportation of bottled water and its production.

Re-using water is very important for the sustainable management of the liquid because it is the easiest way to reach the present objectives. One of the premises of sustainable management of water is to limit the use of drinking water to direct use with the human body. For other uses, it is recommendable to treat, recycle and even use greywater depending upon the application [7]. For example, no one would wash the car or water the garden with drinking water, nor a person would take a shower or prepare food with treated or re-used water. An important recommendation in sustainable management is the harvesting of rainwater and using it for toilets, washing floors, watering plants and even, if it is filtered, for bathing or other domestic use. It has been proven that this water does not have harmful substances or particulates and can be used for drinking and to prepare food.

Some recommendations for the re-use of water are:

- Use rainwater. Rainwater can be used to wash the interior or exterior of the building, to water gardens, in toilets and urinals and even to shower and drink if the necessity is great.
- The use and implementation of areas for rainwater harvesting, which can include roofs, gardens, green areas, water tanks, natural deposits and helping water get to groundwater stores.
- Use of greywater. Harvest greywater and do not let it becomes more contaminated by sewage so that it may be used in toilets and urinals, since they use the most water annually.
- Excesses of water on natural surfaces. This water can be recovered with pumps and storage systems and sent to deposits -where it can be recycled.
- Condensed vapor. In some cases, mechanisms can be used to condense the water found in the environment and use it in the building, generally for applications which do not require drinking water (like toilets, urinals, cooling towers, watering plants, etcetera).
- Retaining rainwater on site. Reduce rainwater waste by filtration to contaminated areas, through roofs and deposits as already mentioned; also, if space allows, employ large drums made with economical materials (like polymer fabric) which contribute to the recovering and management of this precious liquid in a sustainable and ecological way.

Harvesting and management of rainwater for buildings

In Mexico, in spite of the abundance of natural resources including water, it is necessary to begin contemplating the use of rainwater in many of our activities. Construction is no exception. It is needed to help protect the environment by cooperating and aiding in the sustainable management of water: a good option for the conservation and best use of this vital liquid.

Harvesting rainwater means collecting, storing and using the water from the rain. Many of the most common or practical systems for the harvesting of water use roofs of buildings and galvanized steel, fiberglass and –sometimes- polyethylene gutters (though the last one is not recommended because of the environmental impact of its manufacturing process). With deposits made from materials like ferrocement, polyethylene, concrete, asbestos (prohibited), etcetera, for storage in difficult and dry periods. When the water is harvested, it will only be used to water gardens. The filtration is based on sand sediments. When the harvested resource will be considered drinkable, it is recommendable to have or employ other filtration measures [7]. The harvesting of rainwater offers many benefits for the environment including the reduction of contamination in urban zones, aiding in the supply of the resource, avoiding the use of groundwater and other sources of this precious liquid -which can remain stored for future use. After the purification of the rainwater, it can be used by human for drinking and preparing food. The major inconvenience of rainwater is that it can mix with acid rain and become contaminated. If this occurs, it can be treated with chemical agents in order to purify it. When it comes to large bodies of water, the most economical way to treat it is with lime to neutralize the harmful particulates. On the other hand, vegetation and green areas are very helpful to the recovery of water on the site, so the most important arguments when talking about the influence of vegetation on reducing the costs of managing storm water are [8]:

- a surface area of vegetation retains considerable quantity, and mostly a part of that same water never reaches the ground because is being evaporated;
- by capturing rainwater, its runoff is being slowed;
- vegetation cleans water and acts as a filter, intercepting sediments and recycling nutrients;
- allow a better drainage;
- decreases the risk of flooding.

Consider rainwater harvesting in the following situations:

- Areas were the supply and water reserves are scarce or non-existent (arid and dry zones -where there is no natural deposit-, including zones where extraction by pumps is frequent and in abundance).
- Locations where water reserves are contaminated, turning the water into drinking water is very costly and where the water has too many minerals.
- Where natural harvesting is difficult and filtration is quick (deep filtration which happens in many contaminated areas).

The equipment for harvesting and storing rainwater are not that costly or complicated, especially if the area for this activity is designated from the very beginning. The design of the building can take this into account (the design of roofs and terraces, for example). Rainwater supply as a complementary system or as the only system of supply is appropriate for any type of building, from offices to businesses and even homes and hospitals.

For the design of rainwater harvesting systems, it has to be considered the site. Knowing annual precipitation is as important as the building and accessories for harvesting the water. The harvesting system chosen will depend upon the precipitation [3]. The following procedure can be applied to begin any kind of rainwater harvesting in any type of building:

1. Analyze and study the context (along with the other studies of the site). In this first step is necessary to define the characteristics of the landscape, among them, precipitation, ground type, topography, location of groundwater, etcetera. All of this will help in the design of the harvesting system and customize it to the type, size and function of the building.
2. At this stage, and according to the studies completed in the first step, it can be decided what kind of system to use for the harvesting, the dimensions and the location. This step is very important because here is where it is defined the size and cost of the system.
3. At this third stage, it should be defined the methods and construction procedures as well as the construction procedures (gutters, deposits, harvesting surfaces, among others). The price should be evaluated in order to execute the plan.
4. The construction of these rainwater harvesting systems should be planned and designed. They must be considered the limits of the context and the architectural design of the building and that the materials and methods of construction should be in line with the budget [3]. The work on the harvesting system will have to be coordinated with the other mechanized systems for supplying resources to the building (tanks, pumps, plumbing, sensors, consumption controls, etcetera).

By other hand, site plans for land use development should incorporate on-site performance measures as discussed in the Living Green section prior to approval for construction [9]. Storm water will be managed at the site and district levels based on sustainable development principles [9].

CONCLUSIONS

The conclusions from this paper are:

1. In order to incorporate sustainability into the design of a building, one important concept is the sustainable management of water, reducing the consumption of this vital liquid by calculating the water used by plumbing systems.
2. Water should preferably be re-used and residual water with biological mechanisms or chemicals treatments.
3. Saving water can also be achieved through water-saving fixtures and apparatus with either passive or active environmental technology.
4. If rainwater harvesting is chosen, it is necessary to conduct tests on the quality of water to define the treatment and purification systems needed for domestic use.
5. Mexican regulations referring to the sustainable management of water for buildings are rare, which is why lawmakers need to pay attention to this area. This does not only apply to the sustainable management of water, but to the sustainable management of energy, site, materials and construction waste, as well as the sustainable management of the quality and comfort of the interior.

REFERENCES

[1] Kalin, M., Walker, A., Macaluso, J. and Means, R. S. (2002). *Green Building: Project Planning & Cost Estimating*. RS Means.

[2] Secretaría del Medio Ambiente y Recursos Naturales (SEMARNAT). (2001). *Programa Nacional de Medio Ambiente.* SEMARNAT. México.

[3] Ewing, R. (2005). *Best Development Practices*. 2nd edition. American Planning Association. Washington DC, USA.

[4] Kim, J. J. and Rigdon, B. (1998). *Introduction to Sustainable Design.* National Pollution Prevention Center for Higher Education. University of Michigan. USA.

[5] Organización de las Naciones Unidas (ONU). (2009). *Comisión Mundial para el Medio Ambiente y el Desarrollo*. ONU. Disponible en: http://www.un.org/Depts/dhl/spanish/resguids/specenvsp.htm#programme

[6] Texas Water Development Board (TWDB). Center for Maximum Potential Building Systems. (2011). *Texas Guide for Rainwater Harvesting. 3rd edition*. TWDB, Texas Center. Texas.

[7] Legget Sikora, J. (2002). *Profit from Building Green: Award Winning Tips to Build Energy Efficient Homes*. Home Builder Press.

[8] Cicea, C. and Pirlogea, C. (2011). Green spaces and public health in urban areas. *Theoretical and Empirical Researches in Urban Management 6*(1): pp. 83-92. Available via: www.um.ase.ro

[9] Edelman, D. and Triantafillou, M. (2012). A case study of environmentally sensitive planning and urban design in provincial China. *Theoretical and Empirical Researches in Urban Management 7*(2): pp. 22-65. Available via: www.um.ase.ro

[10] Comisión Nacional de Vivienda (CONAVI). (2010). *CEV Código de Edificación de Vivienda*. CONAVI, Gobierno de México. México.