Building rainwater harvesting systems. Doubts and certainties

A. Silva-Afonso
silva.afonso@ua.pt
Departament of Civil Engineering, University of Aveiro, Campus Universitário
Santiago, 3810-193 Aveiro, Portugal

Abstract

Growing interest is being shown in the utilization of rainwater in buildings in many countries, not only for reasons of rational use of water but as a way of reducing flood peaks when it rains, too. Germany and Brazil, for instance, have already established standards in this area. A technical specification has also been published in Portugal recently. It is voluntary and is run by a Portuguese NGO (ANQIP) that promotes quality and efficiency in water supply and drainage for buildings. This paper presents a detailed analysis of this new specification; it looks at certain technical aspects of the conception and design of installation components and the demands of water quality in light of its various uses. Maintenance requirements are also examined, and a certification procedure is created for systems to guarantee the overall technical quality of the installation and the protection of public health. Finally, the standards used in Germany and Brazil are compared and some aspects of those where there is a broad agreement are analyzed. Aspects of those systems where there is currently a certain amount of doubt are also examined, and the differences between the standards used in several countries are indicated.

Keywords

Water-efficiency; rainwater harvesting; domestic water.

1. Introduction

Rainwater harvesting systems in buildings have seen considerable development in a number of countries, notably in Brazil and Germany, both to encourage the rational use of water and to help reduce flood peaks when it rains.
Portugal has also shown increasing interest in rainwater harvesting through an NGO that promotes quality and efficiency in the water supply and drainage for buildings (ANQIP – National Association for Quality in Building Installations).

It should be noted that in terms of the rational use of water the so-called Mediterranean climate does not seem to be favourable to making the most of rainwater since the summers are typically hot and dry and the winters are cold and wet. Typical summer climate usually lasts two or three months.

As the name suggests this climate is only found in the Mediterranean basin (Figure 1), though similar conditions may occur from time to time in southern Australia and on the east coast of north and South America. Most of Portugal, Spain, Italy and Greece enjoy this type of climate.

![Figure 2 – Climate characteristics in various regions of the world](image)

Spain and Portugal, however, are at high risk of hydric stress in the short-/medium-term (Figure 2) and so the harvesting of rainwater in the context of promoting the global water efficiency in buildings may play an important part in reducing this stress as well as helping to reduce flood peaks in the winter.

2. Water efficiency in buildings: The 5R principle

The overall global waste in water use in Portugal is presently estimated at over $3 \times 10^9$ m$^3$/year, which is around 39% of the country’s total water requirement.

With specific reference to the urban supply sector (public and building systems), total waste is reckoned to be $250 \times 10^6$ m$^3$/year, costing about $600 \times 10^6$ €/year.

In terms of figures per person, this amounts to waste of more than 25 m$^3$/year, i.e., near 70 m$^3$/year per family (average family consist of 2.7 persons in Portugal).

Bearing in mind the short- /medium-term water stress forecasts this situation is unsupportable and needs urgent intervention through the application of measures to rationalize water use.
Rational water use in the urban cycle can be summarized as a principle analogous to but more comprehensive than the 3R principle (used for waste) which is known as the 5R principle (Figure 3).

- **Reduce Consumption**
- **Reduce Loss**
- **Re-use Water**
- **Recycle Water**
- **Resort to Alternative Sources**

**Figure 3 – The 5R principle for water efficiency in apartment blocks**

The use of rainwater is included in the fifth R (resort to alternative sources) and, as mentioned above, ANQIP developed a specific technique for this (ETA specification 0701). Note that ANQIP has already devised a certification and labelling model for water efficiency for products and it is currently developing specifications for the recycling of greywater.
3. The Portuguese specification for rainwater harvesting in buildings. Description and comparative analysis

3.1. Introduction

Obviously, as specification ETA 0701 has been formulated by a non-governmental body, compliance with it is voluntary. The specification has 6 chapters (Introduction, Definitions, Legal and regulatory references, General aspects and certification, Technical Provisions and Maintenance), and the certification of these installations by ANQIP is recommended. This recommendation is justified so that the technical quality and public health can be ensured. It implies the prior assessment of the design by ANQIP and the inspection of works and certification of the installers by ANQIP.

3.2. Technical provisions

ANQIP compiled average rainfall maps of Portugal for the rainfall studies (Figure 4).

![Average rainfall map of Portugal (ANQIP)](image)

**Figure 4 – Average rainfall map of Portugal (ANQIP)**

One aspect to which special attention was given was the need to divert the first flush as prolonged dry periods can aggravate the pollution of this water and automatic diverting systems should be installed.
ETA 0701 allows criteria for the time or season of the rainfall to establish the amount to divert. In the first case it is held that an amount corresponding to the first 10 minutes of rainfall, though shorter times (but no less than 2 minutes) may be adopted if the period between rainfalls is no more than 4 days.

The season criterion takes a reference figure of 2 mm of rainfall, though this may vary between 0.5 mm and 8.5 mm, depending on local conditions and the period between rainfall events.

The Brazilian standard also takes 2 mm of rainfall, but the German standard DIN 1989 does not have specific requirements.

ETA 0701 also requires the use of appropriate filters in the connection to the storage tank (to trap leaves, etc.), as to the German and Brazilian standards.

The specification further includes technical provisions to prevent contamination in the spillage of water from the overflow of the system from the first flush and from the rainwater filter mesh, whether infiltrated or in a natural water course.

The installation of a device to reduce turbulence and reduce the speed at which the water enters the storage tank is also required.

Pump suction should be at a slow speed and between 10 and 15 cm below the level of the water in the storage tank, if possible (or through an equivalent system that prevents the suction of floating material or sediment in it).

The ETA also contains various constructive provisions; there is a recommendation that rainwater should be stored in place away from light and heat and that openings should be fitted with anti-rodent and anti-mosquito devices.

A shut-off should also be installed at the start of the system so that if products that may harm human health in the catchment area are used or spilt (on purpose or by accident) the system can be disconnected and the products will not enter the storage tank.

The experts find it hard to agree on the best design for the storage tank. A great many methods can be used: simple ones (German abridged procedure, German simplified procedure, Spanish method, English practical method, Azevedo Netto method, and so forth), and theoretical and probabilistic methods (Rippl method, simulation method, Monte Carlo method, etc.).

The Portuguese specification proposes that the abridged German procedure be used for current situations. It is described in the German standard and yields about 1 m³ per person. Storage period should be no more than 30 days in any case, which is slightly higher than the period established in the German standard (3 weeks).

Like the German standard, the specification contains a table of consumption per installed appliance to help calculate the building’s water needs. The Portuguese table is based on the use of appliances labelled 'A' for water efficiency under the ANQIP certification system since the use of a rainwater harvesting system by non-efficient appliances is not regarded as consistent.

These two tables differ essentially in terms of the amounts for watering outside areas, due to climate differences.

It also stipulates (like the foreign standards mentioned earlier) that the drinking water and non-drinking water systems should be clearly distinguished. Watering and washing appliances, both indoor and outdoor, must be identified and marked with symbols (yet to be defined).

It is also recommended that washing or watering taps should have removable handles/levers (safety key) to prevent improper use.
The installation of a totalizing meter in the section connecting the storage tank to the block’s system is considered, so that the water that does not enter the drainage system (i.e. that used for watering gardens, etc.) is not measured. Questions of quality also arouse significant differences of opinion among the experts. The use of rainwater for washing clothes, for instance, is not allowed in Brazil but it is in Germany. This difference of criteria may be due to the various washing temperatures considered and their effect on microorganisms. The Portuguese specification is nearer the German standard and considers the following possible uses:
- Toilet storage tank flushing
- Washing clothes
- Washing floors, cars and so on.
- Watering gardens, lawns, parks etc.
- Industrial uses (cooling towers, firefighting systems, HVAC, etc.)
It is felt, moreover, that the use of untreated rainwater for toilet flushing should only be acceptable if the water quality is at least up to that of bathing water pursuant to the applicable European directives (Directive 76/160/EEC, of the Council, dated 8/12). It may be disinfected with chlorine or a similar process, if necessary. Clothes should only be washed with rainwater that has had no specific treatment if the washing water temperature reaches at least 55ºC. A microfilter with a minimum mesh of 100 µm should be fitted if the water is to be used for this purpose. If the pH of the rainwater is lower than 6.5 then pH correction may be necessary or appropriate, depending on the materials used in the installation. Discharges into the storage tank from the drinking water system must be undertaken in such a manner that this system is not contaminated. ETA 0701 also contains various notes and recommendations related to the characteristics of the pumping equipment and its installation.

3.3. Maintenance of the systems

Technical Specification ANQIP ETA 0701 contains a maintenance schedule table. It is analogous to that in the Brazilian standard and less comprehensive than the one in the German standard.

4. Conclusions

The efficient use of water is an environmental must for every country in the world. Some countries, like Mediterranean countries, must develop measures to ensure this as a matter of urgency, since water availability could be significantly affected in the short-medium-term. Even though the Mediterranean climate is not really suitable for proper rainwater harvesting this should still be considered in the context of the 5R of water efficiency in buildings. This is why ANQIP, a non-profit Portuguese NGO composed of companies and universities decided to draw up a technical specification for the harvesting of rainwater in buildings, similar to those developed in other countries.
Some aspects still have to be clarified in these systems, especially in relation to the design of storage tanks and, more importantly, in relation to the issue of quality associated with the possible uses of this water.

The matter of tariffs related to rainwater drainage could also be relevant to the implementation of these standards. Note that in Germany, for instance, impermeabilization of the ground is subject to a tax (not yet the case in Portugal) and this can encourage the development of harvesting systems by weighting the recovery of rainwater against such a tax.

It is felt that, despite the different climates occurring in Europe, it should be quite easy, and even desirable, to draw up a European standard for this domain.

5. References


6. Presentation of Author

Armando Silva-Afonso is Professor of Hydraulics at the University of Aveiro (Portugal), Department of Civil Engineering, and Chairman of the Board of Directors of ANQIP, an NGO that promotes quality and efficiency in water supply and drainage for buildings. His specialisation is urban hydraulics and piping systems. In this latter field he is working on mathematical models, such as stochastic models, for demand forecasting and the economic design of interior networks. He has recently been concentrating on improving water-use efficiency in buildings.