The French experience in rainwater reuse in buildings for collective use

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Abstract

Collecting and reusing rain water in buildings are increasing in France. Mostly developed during last years in individual houses, it now also concerns buildings for collective use. In spite of the incomplete regulatory frame in France on these topic and the lack of official documents for appreciating validity and durability of installations, the number of equipped buildings increases mostly in the frame of sustainable development realisations. In this context, CSTB carries out since a few years researches aiming at the end to contribute to the definition of prescriptions based on design, execution and exploitation/maintenance of these installations.
During 2003, a first survey has been carried out, consisting in identifying existing collecting and reusing rain water installations in buildings for collective use in France. More than 40 buildings for collective use have been identified. During 2004, this survey was completed and followed by a description and detailed analysis carried out on a sample of the most representative experiences.
The contribution presents a synthesis of this work. Firstly, the different kinds of buildings concerned by this topic are described with the specific spatial adjustments (schools, apartment buildings, industrial buildings, gymnasiums, stadiums, car and bus depots, shopping centres) as well as the different indoor and outdoor uses of the rainwater are also detailed (water closets, car washing, industrial use). Secondly, the technical solutions used in these existing installations to collect the rain (roof, gutters and drain pipe characteristics), to store it (localisation and materials used for the cistern) and to reuse the water, are analysed. Some propositions for a better efficiency of these installations based on the observed installations are developed.

Keywords

Rainwater; water reuse; sustainable development.

1. Introduction: the current situation

Limited for a long time to areas deprived of natural water resources (places such as islands or high mountain shelters…), the collection of rain water in buildings is now developing in France. For a couple of years the sales of tanks dedicated to the collection of rain water (mainly for garden watering) have increased and today, some companies are offering installations and devices allowing the use of rain water for toilets and even sometimes for washing-machines inside houses.
More recently, local communities and companies in charge of building management have become more and more interested in rain water collection. Many seminars are taking place on the subject. College students are writing reports about it. That interest was generated by a double motivation: on one hand, the HQE (environmental high quality) policy which clearly promotes rain water collection; on the other hand, the idea to find new alternatives to the traditional way of managing rain water.
However, a legal element is somewhat slowing down the realization of these projects. According to the current legislation (mainly the Decree 2001-1220 dated 12/20/01, about waters dedicated to human consumption, to the exception of mineral waters, transcription in French law of the European Directive 98/83/CEE) it is hard to determine whether or not a water, that wasn't submitted to the traditional treatment process, can be authorized for a use within the buildings. In its article 1, the Decree states that waters that shall be considered dedicated to the human consumption are "waters that, either naturally or after treatment, are meant to be drunk, used for cooking or other domestic uses…" But what is a "domestic use"? A strict definition would lead to prevent any use of rain water in the building construction business. Such a strict definition would probably be abusive. For instance, the use of rain water in toilets doesn't require a drinkable quality. The consequence of this vague definition: if the devices used in individual houses are not submitted to any type of control, the use of such installations in collective buildings (residential housing, offices, administrations, high schools and other public premises…) requires a preliminary agreement from the DDASS. Without a clear official position in that matter, the rulings of the DDASS vary from one region of the country to the other.
In such a context, at the beginning of the year 2003, the CSHPF (Superior Council for Public Health of France) decided to create a working group in charge of issuing recommendations regarding the use of rain water for domestic uses.

2 Current situation: the CSTB study

It is hard to get an accurate idea of the extent of rain water collection in France. On one hand, it is indeed hard to gather reliable information when, for instance, the devices located in individual houses are not submitted to any control. On the other hand, it is much easier to identity the use of rain water in collective buildings. That was the goal of the CSTB study initiated in 2003, without, however, having the ambition to be exhaustive.

2.1 The different stages of the study

Between July and November of 2000 the French Ministry of Health led an inquiry with the DDASS. The ministry identified less than 10 installations for rain water collection in public buildings. However, the results of that inquiry seemed a bit limited and apparently incomplete.
As a consequence, with the increasing interest of local and regional communities to realize architectural projects involving a section "dedicated to the collection of rain water", the CSTB, which had been involved in that field for several years (Hilaire, B. et al., 1998; Dérangère, D. et al., 2000), decided to initiate a mission of localization and counting of the different experiments taking place throughout the country for the collection of rain water in buildings for collective use. Identifying and describing existing installations was considered as necessary step to elaborate efficient prescriptions and technical recommendations in this field.
The first stage of the mission was realized in 2003. The first results came from a 4 months study based, not only on the localization of the projects bur also on an attempt to organize the information that had been collected in order to constitute a data base divided in two levels: a general map of the experiments, presented according to several criteria; specific files giving an accurate technical description of the installations when information was available. The information related to this first stage has already been presented (de Gouvello, 2003a).
A second stage was developed in 2004 with the assistance of another student between the months of April and July. The goal was double: first to enrich and update the data base, second to perform a certain amount of inspections of the installations in order to show the different aspects of conception and initiation.

2.2 Map

The map shows the localization of the listed projects, and for each of them the state of the project (realized or to be realized) (see figure 1).
67 projects have been identified: 36 are realized but are in use only for a few years, the 31 remaining are to be realized. These numbers are clearly higher than the number provided by the DDASS survey of 2000 (only 8 existing installations), but also higher than the CSTB survey of 2003 (38 installations realized, 20 to be realized).
Such evolution shows that, in France, rainwater reuse in buildings for collective use is something quite new, with an increasing development dynamic for the last 3 years.
As the map shows, most of the projects identified are located in the north part of the country. France is administratively divided in 96 departments: 2 departments of this area (Nord, Pas-de-Calais) gather more than the third part of the total amount of projects (25 installations, 16 realized). Nevertheless, it is important to notice that this dynamic concerns also other parts of the country: other projects have been identified in 25 different departments (more than 25%).

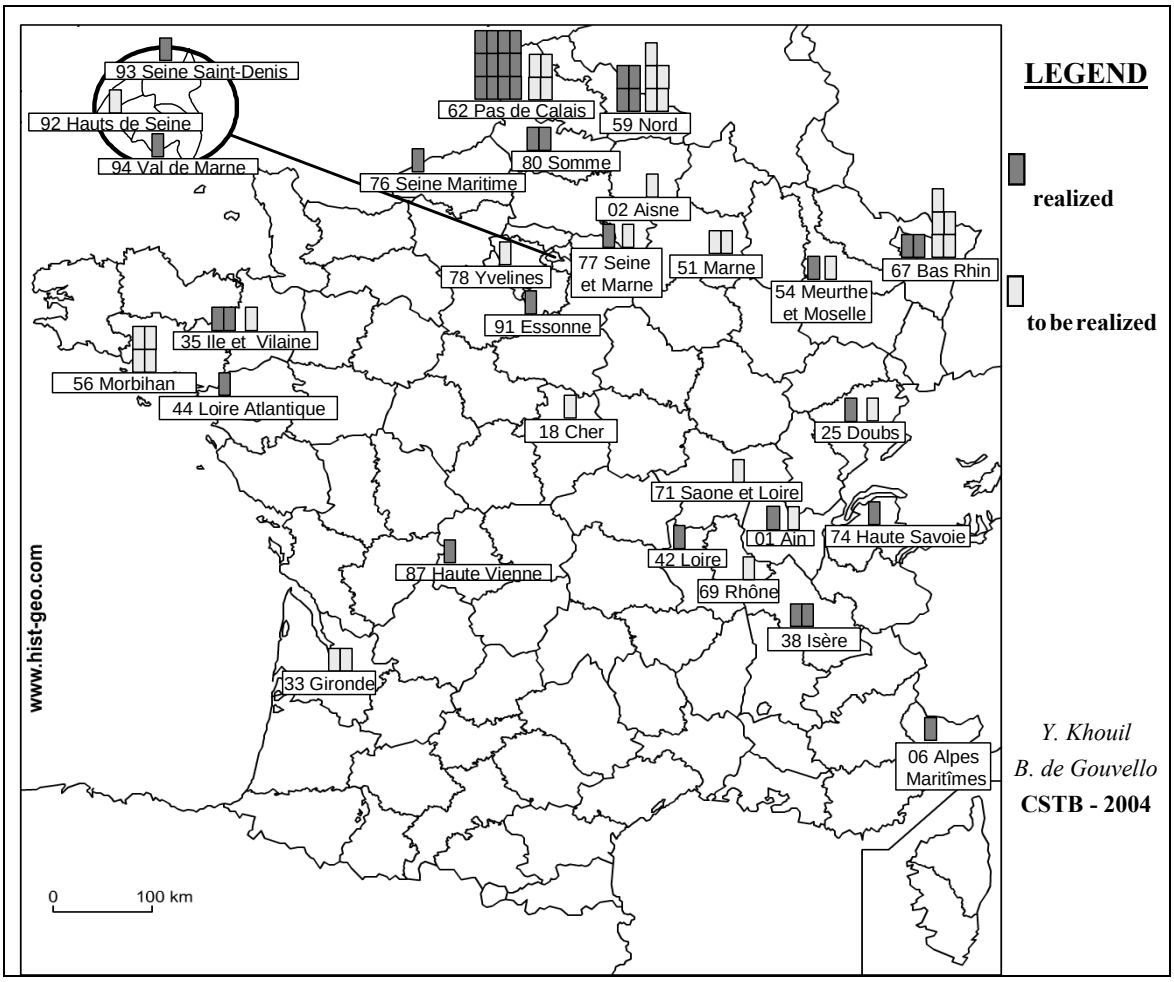

Figure 1 - Map of identified installations

This growing spreading of rainwater reuse projects strengthens the necessity to establish a national regulatory frame in France on this topic, especially for the French health local authorities, who at present have no national criteria to decide whether certain rainwater reuse installations in a building has to be authorized or not.
It is important also to notice that more than half of the total amount of projects were initiated by a local community (region, department, or municipality). That means that local communities seem to be an essential agent to promote and spread this kind of projects.

2.3 Typology of buildings projects

First of all, the rainwater reuse systems apply more to new buildings than to older ones. Nevertheless, at least 10 of the identified projects apply to existing buildings.
The building typology has been defined using the collected information and treating it. The aim of this typology is to describe properly the projects and, at the same, time to aggregate them into several classes, taking into account on one hand the activities within the buildings (especially: function and level of occupation, type of maintenance) and, on another hand, their morphology (especially: size, potential surface for collecting rainwater). The core idea is to target types of buildings for which rainwater reuse is particularly interesting. This approach leads to define 14 classes as figure 2 shows.

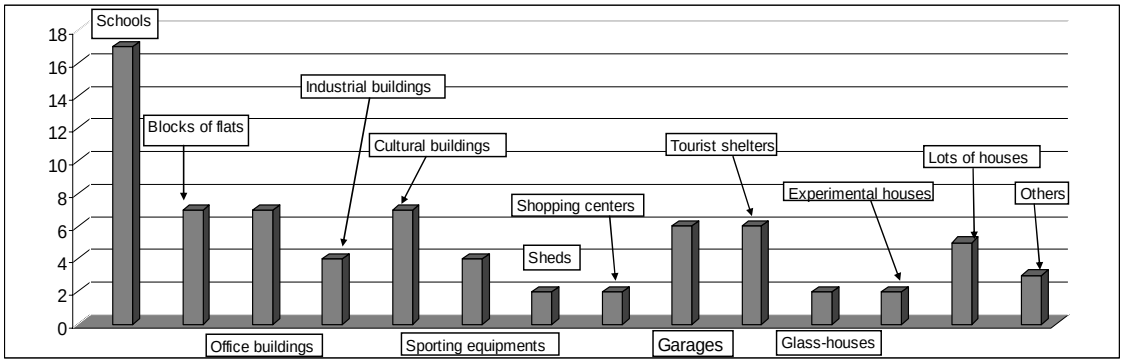

Figure 2 - Types of building projects (2004)

6 classes of building projects particularly stand out.

According to the number of projects, *Schools* is the most important class (17 projects, 10 realized). It can be subdivided into 3 types: grade schools (depending on municipalities), junior high schools (departments) and high schools (regions), being the last category the most important one with 13 projects (7 realized). The region *Nord-Pas-de-Calais* (which includes the 2 northern departments of France) particularly stands out with 6 projects (4 realized). The region decided to generalize the implementation of such installations in all new high school. These first realizations have aroused great interest from other regions and departments or municipalities, which are currently developing rainwater reuse projects in schools.

7 *blocks of flats* projects (6 realized) were identified. 5 were realized a few years ago (between 1996 and 1999). Since then, just one new project has been realized in this category and another one has to be realized, which seems amazingly less than expected. It would be interesting to have an assessment of the 6 projects systems performance to check whether or not this kind of buildings is a good target for rainwater reuse.

7 projects were identified in *office buildings* (3 realized). In most cases, they are administrative buildings. All the identified realized projects are localized in the *Nord-Pas-de-Calais* region. Nevertheless, 3 of the projects to be realized concern other parts of France.

Also 7 projects (with 3 realized) were identified in *cultural buildings*. This category includes auditoriums, libraries, showrooms and village halls from different parts of the country.

6 projects (3 realized) are in *tourist shelters*: rural gîtes, recreational facilities and camping sites.

For the three last categories described, there are more projects to be realized than already realized. This shows the potential of development for these kinds of buildings.

6 projects (4 realized) are garages. “Garage” here means a place where cars are maintained and/or repaired, whether this maintenance is a commercial activity or not.

5 projects (2 realized) deal with *lots of houses*. All these projects are localized in the eastern part of the country. The development of this kind of projects has to be expected elsewhere, due to the evolution of the Urbanism regulation rules.

Finally, 4 projects were identified in 2 other classes, which can become interesting targets for rainwater reuse projects in the future: *industrial buildings*, as the example of Renault-Maubeuge shows (Thomas, J-S. et al., 2002); *sporting equipments* like gymnasiums and stadiums.

2.4 Typology of collected rainwater uses

2.4.1. Main Uses and others

4 main uses of the collected rainwater have been identified (see figure 3).

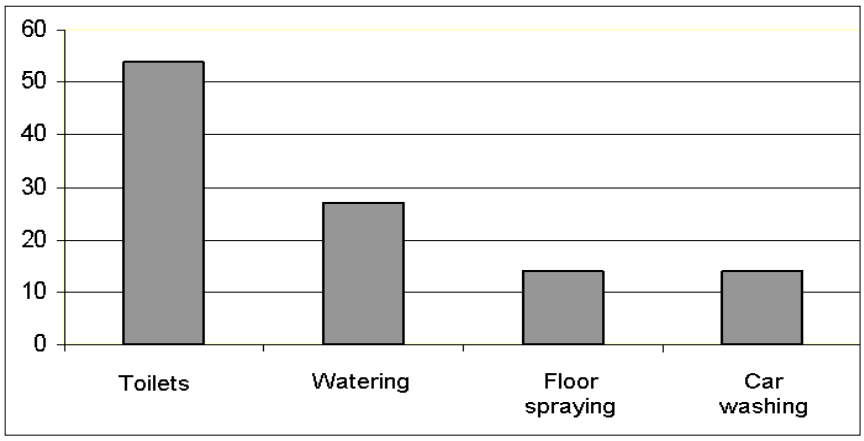

Figure 3 - Main uses of collected rainwater (2004)

Toilets (54 projects): the collected rainwater is used to supply the flush through a specific network. This is the more common use.
Watering (28 projects): the watering is realized using a technical tap, most of the time situated outdoor.
Floor spraying (14 projects): the floors washed are: indoor or outdoor car parks, rubbish rooms, common parts of the buildings,…
Car washing (14 projects): the car washing is realized indoor or outdoor, using a technical tap provided by collected rain water.
Several other identified uses have to be mentioned: industrial uses, glass washing, ornamental lake supplying, fire network supplying, concrete preparing, boat washing, and cooling tower supplying. Although these uses nowadays appear only in a few numbers of projects, they draw potential ideas for future projects.

2.4.2 Indoor and outdoor uses

The uses identified below are indoor (toilets, indoor floor spraying, industrial uses,…) and outdoor ones (watering, outdoor floor spraying, ornamental lake supplying,…). This differentiation is important according to several regulatory questions. Is it possible to have different water networks for different uses within the same building? Does toilet flushing require drinking water quality? Is necessary a tax payment for sewerage in case of rainwater collection?
In many cases (23 of the 67 identified projects) the collected rainwater has 2 or 3 different uses, with a mix of indoor and outdoor ones. Most of the time, the uses combination is: **toilets** + **watering** or **toilettes** + **floor spraying**.
Moreover, there is an obvious relation between the uses and the building projects classes. In schools, blocks of flats and office buildings, the main targeted is toilet flushing (in some cases, cumulated with watering or floor spraying); in garages, the collected rainwater is used to wash cars…

3 Lessons from experiences

3.1 Inspections of installations and in situ experiments

During the last 5 years, about 10 rainwater reuse installations in buildings for collective use were inspected or were in situ experiments watched over by the CSTB (see table 1).

Localization	**Building type**	**Rainwater use**
01 - Meillonnas	**Block of flats**	**Toilets - Floor spraying**
59 - Caudry	School	Toilets – Watering - Floor spraying
59 - Douai	School	Toilets - Watering
59 - Dunkerque	Industrial building	Industrial use
62 - Calais	School	Toilets – Watering - Floor spraying
62 - Loos en Gohelle	Office Building	Toilets
76 - Petit Quevilly	**Block of flats**	**Toilets**
77 - Champs/Marne	**Experimental House**	**Toilets (simulation)**
87 - Limoges	School	Toilets - Watering
91 - Grigny	**School**	**Toilets**
93 - Saint-Ouen	Block of flats	Toilets - Floor spraying

Table 1 – List of inspected installations and experiments in situ
(Experiments watched over by the CSTB are indicated in bold)

The inspection of rainwater reuse installations were realized according to a specific methodology, including the inspection of the technical premises; the identification of all points of use; a roof examination; interviews of the administrative and technical managers of the installation; the drawing of the installation scheme and a brief inspection report including photos.
The information on experiments watched over by the CSTB is more detailed: it includes consumption data and water quality analysis (see de Gouvello, B. et al., 2004)

3.2 Functional description of an installation

Every rainwater collecting and reusing system in buildings can be divided in five *main functions*: rainwater collecting, water refining, storage, water delivering, and signalization and information. Each one of these functions can be possibly subdivided in *elementary functions* to which particular technical devices can be associated.

3.2.1 Rainwater collecting

This main function contains two elementary functions: *collecting* itself (assured by the surface of the building on which the rainwater to be collected falls and flows down) and *conveying* towards cistern (through gutters, drainpipes, manholes and buried pipes).

3.2.2 Water refining

Water refining can be divided in the three elementary functions of *weeding out* (at the head of drainpipes*), water treatment upstream* and *filtration downstream* storage cistern.

3.2.3 Storage
The storage consists in three elementary functions: *storage* itself (high capacity container), *level gauge* (automatic or not) and *storage regulation* (which contains two parts: a contact for tap water and an overflow).

3.2.4 Water delivering
Water delivering can be divided in two elementary functions: *water pressurizing* (pumps and pressurizer), *supplying water* to points of use (pipes).

3.2.5 Signalization and information
The signalization and information function consists in three elementary functions: *differentiation of indoor networks*; *users' protection*; *basic technical information* to help the ordinary operating and maintaining of the installation.

3.3 Comments on inspected installations

It is possible to make some comments on the implementation into practice of the *main functions* and details for some *elementary functions* on the basis of the inspected projects.

3.3.1 Rainwater collecting
The collecting surface preferentially used in the different identified installations is the roof. An additional collecting disposal has been used in one case on parks: this solution appeared to be a source of difficulties, the contents in hydrocarbon being of low compatibility with the use in toilets (even after a clarification tank).
Roofing materials used are: steel or aluminium sheets (the most widely used solution), zinc, stainless steel, copper, tiles, slates, gravelled roofs, flat concrete roofs. In most of the cases, roof materials and shapes are defined by the architect without considerations on possible pollution of rainwater by, which is chosen by the architect. On a same site, rainwater collecting can be realized from a roof made of different materials.
In most cases, no specific cleaning procedure has been defined neither implemented.

3.3.2 Water refining
Gutters and heads of pipes are badly protected. When installed, gratings are usual ones, too wide-meshed to be efficient for rainwater harvesting.
There is no always water treatment upstream storage. Without an efficient upstream water treatment, sedimentation in storage is growing and the storage has to be maintained more frequently.
Several upstream treatments were observed: Clarification tanks or cleaning out, which consist in leaving water to settle in a space, being the water borne solid elements settling at the bottom and the water collected above a certain level only; Wide-meshed sieves (meshes between 2 and 5 mm), which retain elements from water and eliminate them through the public network of rainwater drainage; Self-cleaning filters (tilted grid or whirl filter), which eliminate elements of a significantly smaller size (down to *100-200 µm* according to the models); Tanks for thin filtration (limiting to *5 µm* at the exit), more rarely used because it requires a succession of different layers and also a minimum

of support and maintenance, but offers the advantage of providing storage tank with high quality water, which greatly simplifies the problem of cleaning this tank.
Downstream treatments observed in the inspected installations were: small meshed filters, micro filters and UV lamps.

3.3.3 Storage
The more common types of storage observed are: concrete and metallic buried tanks; underground tanks in PEHD; steel buried tanks; and open air ponds.
Concrete buried tanks are the most common solution. Very often, they are buried under a green area. In cases where it is buried under a road, a specific protection is installed. Metallic tanks are more unusual.
Underground tanks in PEHD are also frequently used. This solution enables to adapt to situations where the excavation necessary for the installation of a buried tank is not possible, either due to a lack of space, or due to building site difficulties. Some of the tanks made of PEHD are modular. Thanks to that specificity these tanks can be installed in battery in cellars once the building construction is finished, the dimensions of each modulus authorizing a motion through the doors.
Open air pond is a relatively marginal solution. It generates problems in terms of water quality, the collected water having to be imperatively filtered before its reuse. However such a solution offers a landscape advantage because it associates a pleasantness function to a strictly speaking storage function.

3.3.4 Water delivering
The number and characteristics of the pumps differs from an installation to another. The pumps are not always chosen according to the characteristics of rainwater.
A lack of maintaining is also noticeable.
Protection against public network pollution is not always assured. The more efficient devices for such function are backflow preventers AA type or BA type, which are installed in some installations.

3.3.5 Signalization and information
Three practices in the domain of signalization can be pointed out.
In the case where collected water is used inside the building, the inner piping system conveying this water is in most cases clearly differentiated from the system conveying public water. This distinction can be made either by painting the pipes of the reused rainwater system in a different color, or by putting every X meters a clear indication (example: *cold non-potable water*).
At the level of points of use located inside as well as outside the building, appears in most cases (but not everywhere) a sign explaining *« non potable water »* or *« hazardous to drink this water»* and/or a pictogram representing a water glass crossed. In a certain number of cases, the use of taps is protected (removable handle, barrel preventing the opening of the tap with single pliers), these taps being only handled with a specific tool.
Finally, it is advisable to point out that in many installations (in particular in blocs of flats), sanitary authorities have required that reused rainwater distributed shall be colored.

4. Conclusion

The collection of rain water in buildings for a collective use is developing in France. The counting and localization realized by the CSTB allows bringing to the fore the different types of buildings (schools, residential buildings, offices …) and uses (toilets, watering, floor and street spraying…) where this idea seems to have a future.
However, today, without a clear legislation regarding the sanitary and technical aspects of the rain water collection, the current projects suffer from many weaknesses. It is urgent to solve these problems and complete the information. The regular inspection of the existing installations will provide us with clues that need to be deepened.

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Authors presentation

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