Rainwater harvesting: What are the potential effects of roof maintenance on runoff quality? France as an example

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Abstract

Currently rainwater harvesting is more and more popular in the world. The aim is reduce drinking water consumption in developed countries or create a point of access for water in developing countries, for drinking water or for plants irrigation. For developed countries the problems of rainwater re-use can be linked with micro pollutants contamination. Hence we underline a possible source of biocides and especially of quaternary ammoniums in rainwater stocked, which can be a source of exposition. For developing countries the problematic is link with health by drinking water access. Indeed some authors showed how contaminated rainwater is. Not really by chemical products but by bacteria.

Keywords

Rainwater harvesting, Re-use, Roof runoff, Biocides

INTRODUCTION

Nowadays, rainwater harvesting and re-use are more and more encouraged, mainly for countries where water resources are rare, since they may prove to be a possible solution. As such, a lot of systems have been created to collect these waters. Moreover in some countries like France, tax reductions have been set up to promote rainwater harvesting ntoine and furthermore the use of these waters in house has been authorized (Governmental decision, 08/21/08). The matter pertains more to the diminution of drinking water and not its access issues. Nevertheless, no studies have been undertaken to evaluate the possible contamination of roof runoff. Indeed it is known that roof materials can be a source of trace metals (Robert-Sainte, 2009) or organic micro-pollutants (Burkhardt *et al.*, 2007).
Furthermore, in developing countries, some studies have begun to establish the current level of rainwater contamination. As a matter of fact, before drinking rainwater is made possible, it has to undergo verifications in order to meet the water quality guidelines for drinking water. Indeed, especially on order to drink rainwater, it is essential to verify that this water meets the guidelines of water quality for drinking water.

MATERIAL & METHODS

We used a methodology divided into 2 parts (Van de Voorde *et al*., 2009). Firstly, we listed as exhaustive as possible the different products for roof treatment. This was realized thanks to

Internet and visits to hardware stores. After listing all of these products, it has been possible to define the practices linked with the utilization of these products. Furthermore, with the Security Data Sheets (SDS) of the listed products, we were able to determine the molecules used as biocides. Thence we searched in scientific literature to evaluate the toxicity of these compounds and the related risks.

After this part, a survey has been conducted to infer about the success of the roof treatment and thus professionals were interrogated. We used a classic approach by poll to comprehend precisely how a roof treatment was undertaken. Finally, we made research on literature in order to have a description of systems used in developing countries, the contamination level of the rainwater collected and the purpose of rainwater harvesting.

RESULTS AND DISCUSSION

Situation in France

Methods of treatment

Concerning roof cleaning, 4 techniques have been identified: primary cleaning, fungicide treatment, waterproofing and paint. The Table 1 presents the number of products for each practice.

Table 1: Listing of the products

Product type	Number of products	Utilisation
Primary cleaning	3	Primary elimination of plants
Fungicide	18	Destruction of fungi and incrusted lichens
Waterproofing	7	Increase of resistance to water for porous material
Paint	4	Embellishment / Waterproofing

As we can see the market analysis shows a larger offer for fungicide treatment, with a wider variety of available products (18/32). Waterproofing is also well represented (7/32). This has been verified not only on commercial web sites but also in hardware stores.

These results have been proved by the poll for professionals. Indeed, it reported that the most important treatment realized is fungicide treatment which is illustrated in the Figure 1.

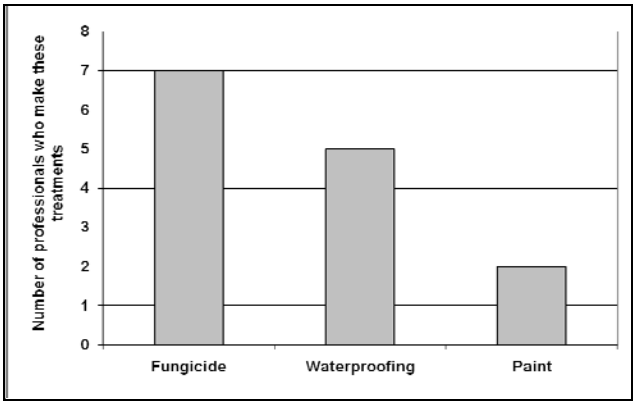


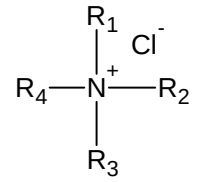
Figure 1: Roof treatment made by professionals

As we can see, primary cleaning is not present in this figure. Actually these treatments are included in fungicide products used by professionals. In addition, paint is the less used treatment.. This can be explained by the fact that painting induces a fusion of all tiles which can prove to be a huge problem for the future roof maintenance (e.g. substitution of tiles). Unfortunately, this poll cannot be considered as fully representative due to the contribution of only 7 professionals. Hence, caution was the main concern when dealing with the conclusions.
As a result we isolated the most important technique used: fungicide. Subsequently, the molecules present in the products were identified.

Biocides used

With product tags and SDS, the compounds acting as biocide molecules were listed, of which one family of molecules was pointed out: the Quaternary Ammonium Compounds (QACs). These molecules are constituted by a central Nitrogen atom linked with 4 alkyl chains yielding into a permanent positively charged Nitrogen atom. The general QAC scheme is as follows in Figure 2:

General formula



Alkylbenzyldimethylammonium
(n° CAS : 8001-54-5)

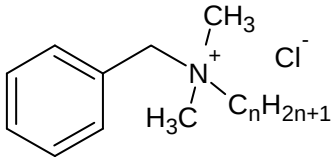


Figure 2: General formula and most known QACs

We can see that the nature of the different groups can vary. For fungicide products, the molecule used is the alkylbenzyldimethylammonium chloride, called benzalkonium or in short, BAC. Benzalkonium is more and more used in disinfectants, for preservatives or in household products (Kummerer, et al., 1997). This molecule is declared as dangerous for aquatic environment. Indeed its biocide properties can among others destroy bacteria (Kummerer, et al., 2002, Sutterlin, et al., 2008), algae, fish and also crustacean, with EC50 from 280µg/L for fish to 5.9µg/L for crustacean (EPA, 2006). Moreover, QACs are generally allergen upon mere contact on the human skin causing irritations. (INRS, 2005). Furthermore it has been reported that some people can have asthmatic reactions (Hemery, 2008, Sènécal-Fouquoire, et al., 2001).
Hence, upon treating his roof, a private individual storing rainwater will only collect roof runoff contaminated by quaternary ammoniums compounds. Consequently, not only could this create a risk for the user (e.g. if he washes his car) in producing an allergy, but also in sewers, in wastewater treatment plants or in rivers due to the biocide effects of the molecule.

Developing countries

The third part of Target 1 of the Millennium Development Goals (MDG) is to halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation. The MDG has been adopted by 192 United Nation member states and at least 23 international organizations. In this light, rainwater harvesting is a good way to collect and store drinking water on a small-scale (Mwenga Kahinda *et al.*, 2007). Moreover, this technique is not a new concept in Africa. As describes Duncker (2000), in KwaZulu-Natal and the Eastern Cape (South Africa),

rainwater is the major source of drinking water during rainy season. These systems are more developed in rural area.

Gleick showed in 1996, that it existed a link between clean water access and adequate sanitation and diseases propagation. Consequently it is essential to evaluate the bacterial as well as chemical quality of rainwater stocked.

In this domain, a review of Mwenga Kahinda *et al*. (2007) shows that some studies underline that the quality follows the international guidelines of drinking water, whilst others prove the poor quality level of rainwater.

For the contaminations, studies have been undertaken all over the world. For example, in New Zealand, Simmons *et al*. (2000) lead a work to measure trace metals and bacteria in rainwater. The contamination level for trace metals met the New Zealand drinking water quality guidelines. Nevertheless the bacteriology proved to be too high to declare the water drinkable according to World Health Organization.

Similar results have been found in India (C-3 Report, 2000). Indeed the conclusions of this report were that the bacteriological factor meets the guideline in only 10% to 70% of the cases. But on another hand, the report underlines the fact that chemical contamination is a very important parameter. Furthermore, the report highlights the fact that if bacteria can be removed by boiling water, it is not the case for dissolved pollutants.

CONCLUSIONS

As we present in this paper, not only in developing but also in developed countries, rainwater harvesting and re-use are contemporary issues. Moreover although the situation in these countries is clearly different, we can see that in both cases problems of pollution emerge. The risks can be chemical by the spread of biocides, or it can by bacteriologic by the development of algae, fungi or bacteria.

Consequently, if in developing countries it is important to study the maintenance of the roof and the storage tank, in developed countries, however, an important work has to be carried out to establish the current techniques of rainwater harvesting and to guide the population in case of possible health risks.

AKNOWLEDGMENTS

This study is financed by Conseil Regional d'Ile de France, in collaboration with Laboratoire Eau, Environnement et Systèmes Urbains (LEESU), Eaux de Paris and Centre Scientifique et Technique du Bâtiment (CSTB).

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