Is it dangerous to collect rainwater from bitumen roofs ?

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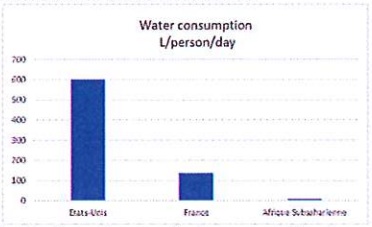
Introduction

Man is aware of his impact on the environment and especially on water management (pollution, global warming, overconsumption, waste ...). Water is a vital and scarce resource. And yet, its consumption continues to increase especially in our developed countries (1).



That's why it's important to take action every day to preserve it. Thus in an eco-citizen approach, the college is equipped this year with a rainwater collector.

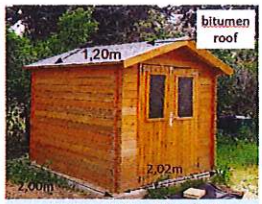
In the Weather Club, we first explained the importance of good water management, secondly we learnt about the Garden Club's activities (cultivated area, watering habit ...) and in particular its rainwater collector (size, location, maintenance...).

Then, we realized that we weren't sure of the emplacement of the rainwater collector because of the bitumen roof where the water was collected : is it dangerous to collect rainwater from a bitumen roof ? This is the part we have decided to developpe here.

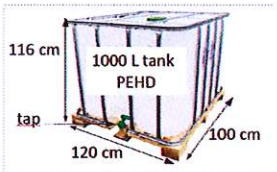
Context

The college has been involved in a labeling process since 2017 by launching the Éco-École program. Éco-École is an international program of Education for Sustainable Development developed in France by the French Office of the Foundation for Environmental Education in Europe (OF-FEEE).

In the spirit of eco-citizenship, the Garden Club has been equipped this year with a rainwater collector to water the educational garden. It is planned to collect rainwater from the roof of the shed where the garden tools are stored.



Picture and size of the shed



Picture and size of the rainwater collector

The rainwater collector will be installed next to a gutter. The rain that falls on the roof of the shed is channeled through the gutters and is collected in the tank. A grid filter is installed upstream mainly to stop the leaves. Regular maintenance of the rainwater collector is still necessary. A tap located at the bottom of the tank is used to collect the water.

When we visited the educational garden, we were surprised to learn that we would collect rainwater on this little black roof. We thought about the water that runs off the roads when it rains and becomes polluted. We didn't really know if a roof could pollute the water as roads do and what bitumen was (composition, manufacturing, impact on health, use ...).

Roof water pollution

Rainwater does not escape pollution. This occurs in two stages : during the crossing of the atmosphere (carbon dioxide ...), then during runoff. The rain water takes in the pollutants accumulated on different surfaces before the rain. The quality of rainwater is highly dependent on the quality of the air and especially the type of surface on which it runs. For water running off roof, the pollution sources are (2) :

- natural pollution : leaves, animal waste, dust ...
- metallic coatings : copper, zinc, lead, tin ...; This is not our case.
- insulation / waterproofing of flat roofs : hydrocarbons ;
- roof maintenance : weed killers, defoamers. This is not our case.

We understand why rainwater is not considered drinkable. Therefore, we have the obligation to indicate with a "non-drinking water" sign all rainwater supply points.

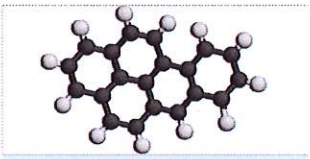
In our situation, the natural pollution is limited thanks to a filter placed before the tank. What about the hydrocarbons pollution ?

Picture of a natural pollution on the shed roof : the pollen

Hydrocarbons and bitumen

Bitumen (3) is a mixture of hydrocarbons from the distillation of petroleum : it is mainly composed of carbon (C) and hydrogen (H) atoms. So, bitumen is the source of pollution by hydrocarbons. It is impossible to give a precise chemical description of the bitumen composition. It is used for its properties (adhesion, deformation, impermeability). It is found in the construction of roads.

Before 1993, coal tar was used. It is classified as carcinogenic by the European Union especially because of the presence of BaP (benzo[a]pyrene). In large quantity, BaP can lead to skin, lung and bladder cancer. That's why it's no longer used. Tar and bitumen are still being mistaken : the terms "tarring roads" is still used for instance.



molecular model of the BaP ($C_{20}H_{12}$)
a polycyclic aromatic hydrocarbons (PAHs)

In bitumen BaP is found at an extremely low level : 0.1 to 2.5 mg / kg. In tar, it is 8,400 mg / kg to 12,500 mg / kg (4).

Results

At room temperature, BaP is an odorless yellow crystal (5). We decided to compare its properties with a crystal we know better : sodium chloride (or salt).

chemical species	benzo[a]pyrene (5)	sodium chloride
Solubility at 25°C in water	0,003 mg/L	360 g/L
Density	1,351 (2)	2,12

The solubility of a chemical species in water is the maximum mass of this species that can be dissolved in 1L of water. When water is a good solvent for salt, it is not the case for BaP : BaP is insoluble in water. Therefore, it is possible to collect the pollutant with filter just like dust in vaccum.

Indeed, the density of BaP is greater than 1 (density of the water). Therefore, the yellow crystal falls down the tank just like salt crystals at the bottom of a glass of water before mixing.

In conclusion, the hydrocarbon pollution can be avoided by decantation and filtration.

According to the INRS (6), in normal conditions of temperature and atmospheric pressure, bitumen does not present any danger. On the other hand, when the bitumen is heated to temperatures that may reach or exceed 210°C, it emits fumes that may contain dangerous substances (polycyclic aromatic hydrocarbons PAHs etc.). The toxicity of PAHs is very variable : some are weakly toxic, while others, such as benzo(a)pyrene, have been known carcinogens for several years. (4). That's why we did temperature measurements on the roof. We have measured a maximum of 45°C and it reaches 25°C only when the roof is wet. Those values are far from 210°C. Therefore, we consider that this pollution is not dangerous for our use : watering the garden.

A roof temperature measurement with the infrared thermometer

In addition, there is a law in France that stipulates that "you are not allowed to use rainwater [...] if the downstream of your roof contains asbestos cement or lead". So, it doesn't exclude bitumen roofs.

Conclusions

Our goal is to educate our friends and families : we must preserve water by taking into account our environment and our daily actions. Simple and inexpensive gestures are possible : it is 119€ for the rainwater collector, 0€ to turn off the water while brushing our teeth. We had no doubt about the ecological and economic issues of the installation of the rainwater collector to water the educational garden. But we needed to check its location : collecting rainwater from the bituminen roof of the shed.

The bitumen is used here to make the roof of the shed waterproof (impermeability). But, it contains benzo[a]pyrene (BaP) among other hydrocarbons pollutants. It's a carcinogenic substance.

Thanks to our research, we are reassured : we have not found any worrying information prohibiting the use of rainwater from bituminen surface. BaP is present in a very low proportion. In the conditions for our use (45 °C max), there is no danger with bitumen. But, we advise all users of the rainwater collector to not neglect its maintenance and not to use the mud deposit that may form at the bottom of the tank.

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