Drinking the rain: Quality issues and technological advances

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INTRODUCTION

With growing pressures on natural resources worldwide, rainwater harvesting (RWH) is fast becoming a viable drinking water supply for an expanding population. Notwithstanding, microbiological and chemical contamination from roof-top runoff has been detected above water quality guidelines, posing a health risk for consumers. Our research explores the use of silver ions, combined with filtration and settling mechanisms, as a safe and affordable model for purification that can be applied at a small scale. Pilot systems have been installed and monitored for this study in rural communities of San Miguel de Allende, in central Mexico, where groundwater is either lacking or contaminated.

Converting rain into drinking water

1.

Rooftop collection.

Gutters and standard PVC pipes are used to channel the rainfall towards the treatment and storage facilities. All the systems used for this study were installed from 2007-2009 (Table 1).

2.

Table 1. Rainwater harvesting systems analysed.

	ID Community/sampling site	Roof area (m2)	Consumption (m3/year)	Cistern Type	Cist. size (m3)
1.	Rancho Nuevo Villa Guadalupe	80	10.0	TK	5
2.	San Antonio de la Joya	82	11.6	OG	17
3.	Don Juan	49	8.0	OG	7.5
4.	La Aurora	60	8.8	TK	10
5.	San Miguel Viejo – Classroom	98	32.0	OG	45
6.	San Miguel Viejo – Kitchen	60	16.0	UG	17
7.	Augustin Gonzalez – Clinic	140	NA	UG	45
8.	Augustin Gonzalez - School	350	48.0	UG	80
9.	El Salitre	200	30.0	OG	17

Notes: Systems are all installed in schools, except for a rural clinic (#7).
OG – Overground geomembrane; UG – buried/underground cistern with geomembrane liner;
TK –pre-fabricated plastic tanks (5,000 l) with lids.

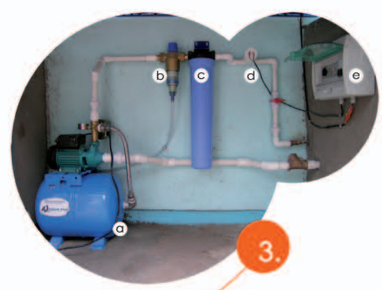
Cistern and settling tank.

A 450 L plastic tank receives the incoming water, acting as a barrier for heavier solids and particulate matter. It also performs the function of a 'first flush' device, disposing of the first litres of rainfall. An important removal of bacteria and organic matter is observed in this step alone.
The cistern is made of high quality geomembrane, a material suited for the storage of drinking water. Capacity varies according to demand and catchment area. Cisterns and tanks are covered to avoid contamination.

4.

Purified drinking water.

Through taps, drinking fountains or school kitchens like the one shown, children, staff and visitors safely use and consume high quality water, collected from the rain that once fell over their very own rooftops.



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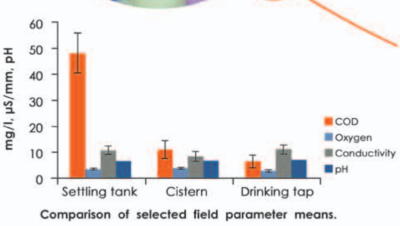
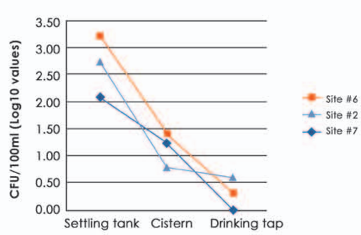


Comparison of selected field parameter means. Standard error of the mean (SEM) values shown in black line.



Total coliform removal efficiency for selected sites.

Disinfection efficiencies of up to 99.9% are observed, with the settling tank alone accounting for at least 85% of this. The quality of untreated runoff was also found to be much better in cleaner roofs without overhanging branches, suggesting the importance of adequate maintenance.

Purification and filtering.

The system consists of the following stages:
a) Pressurized pump to provide water on demand.
b) Stainless steel filter, removing particles larger than 100µm.
c) Cartridge containing coconut-shell activated carbon (GAC) and Kinetic Degradation Fluxion (KDF) filtration media.
d) Silver cells or electrodes*.
e) Silver ionizing unit.

*Low DC voltages are applied alternatingly to cells, ensuring an even dispensation of Ag+ ions into the water.

Methodology.

A number of water quality parameters were evaluated, combining field tests and the support of a local lab for immediate results, with cation and anion measurements performed at the Wolfson Laboratory for Environmental Geochemistry, UCL-Birkbeck, in London using an ICP-OES (Table 2).
Samples were taken at three points of the treatment process:
1. Settling tank
2. Cistern
3. Drinking fountains

Table 2. Mean values for element compositions in mg/l (SEM shown in parenthesis).

Cations	Settling Tank	Cistern	Drinking Tap
Ca	9.75 (1.88)	7.85 (3.05)	9.93 (2.14)
K	3.21 (2.07)	1.52 (0.47)	1.42 (0.18)
Mg	0.31 (0.08)	0.36 (0.23)	0.36 (0.15)
Na	5.26 (4.71)	3.23 (1.67)	5.17 (1.97)
P	0.08 (0.03)	0.04 (0.01)	0.012 (0.002)

Anions	Settling Tank	Cistern	Drinking Tap
F	0.22 (0.01)	0.23 (0.09)	0.27 (0.1)
Cl	2.52 (0.56)	1.48 (0.36)	2.26 (1.04)
NO_3	35.58 (1.38)	3.84 (1.36)	3.7 (2.02)
SO_4	49.58 (1.64)	4.51 (1.37)	6.16 (1.22)

CONCLUSIONS.

We conclude that the system with all its components, including settling tank, filters and silver ionizer, has the potential to provide quality drinking water from harvested rain, employing low concentrations of silver ions (<5 ppb). Extreme cases where cisterns are heavily contaminated by external sources may require higher Ag dosages, which can be achieved by increasing the voltage on the ionization device. World Health Organization guidelines allow up to 100 ppb without any observed health effects*. We are currently working on lab-scale models at UCL to better understand the possibilities and limitations of the system, as well as finding new ways to enhance its efficiency.

* WHO, 2008. Guidelines for Drinking-water Quality 3rd ed., Geneva: World Health Organization

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