# DISCOVERING THE QUALITY OF HARVESTED RAINWATER

## 2019 CLIMAS FELLOW

NORMA VILLAGOMEZ-MARQUEZ
DEPARTMENT OF ENVIRONMENTAL SCIENCE
January 2020

## Contents

## Executive Summary

Rainwater harvesting has been used as a water conservation measure, particularly where other water resources are scarce. Today, interests in harvesting rainwater are rising as four billion people worldwide suffer water shortage at least one month a year. Historically, the capturing and storing of rainwater goes back over four thousand years to when we first started to farm the land and needed to find new ways of irrigating crops. In dry climates, such as Tucson, collecting rainfall often meant the difference between life and death. With urbanization, however, the need to conserve water fell away in the last thousand years. Nowadays, global water shortages return us to this old-fashioned, low technology and critical part of sustainable living.

Project Harvest engages community members through citizen science about the health of their harvested rainwater, soil, and plants. This project has over 200 participants in four communities throughout the state of Arizona collecting environmental samples over a three-year period. Generally, rainwater is relatively free from impurities except those picked up by rain from the atmosphere, but the quality of rainwater may decrease during collection and storage. However, national rainwater quality standards for both potable and non-potable domestic usages are yet to be established.

For these reasons, the aim to generate a dataset that informs guidelines and recommendations for safe non-potable use of rainwater while empowering underserved communities in the sustainable production of their own food sources. In efforts to encourage water conservation measures at a younger age, we set out to discover just how much the children of Project Harvest participants know about the citizen science work their parents are doing. Therefore, the objective of this study was to asses the basic knowledge of

these topics through illustrations from children who have been exposed to rainwater harvesting directly and/or indirectly. Children aged 9 and 10 were provided with color pencils, a blank canvass and were asked to illustrate their answers to four rainwater harvesting related questions, included below.

- Question 1: Why is it important to harvest rainwater?
- Question 2: How does your family harvest rainwater?
- Question 3: What do you think could be in harvested water, other than water?
- Question 4: How does your family use harvested rainwater?

The illustrations produced by children aged 9 and 10 were remarkably consistent. Most of the children in this study could address question 2: How does your family harvest rainwater? and question 3: What do you think could be in harvested water, other than water? Typical rainwater collection systems included roofs, buckets, cisterns, and gutters. Interestingly enough, there were also drawings that included non-traditional forms of collecting rainwater which included materials such as clay and bamboo. Unfortunately, none of the children that participated could address question 1: Why is it important to harvest rainwater? Three of the children that participated illustrated knowledge of rainwater contamination both microbial and organic as well as basic rainwater treatment in the form of nets and/or sieves. The microbial contamination was demonstrated by way of bird defecation onto the roof of a home. The organic contamination was depicted by the presence of automobile exhaust rising onto rain clouds.

In the future, we aim to (1) increase the number of children participants (2) include a larger age gap (3) as well as expand the number of questions to increase basic water conservation understanding and rainwater uses.

## Introduction

Today, about 40% of the global population lives in arid and semi-arid environments, like Tucson Arizona. In these geographic areas, water scarcity concerns are very common. Thus, rainwater harvesting has been used as a water conservation measure, particularly where other water resources are scarce. In my community, residents are collecting rainwater for non-potable uses such as gardening and watering of green spaces to ease future Colorado River shortages. Harvesting rainwater is one possible alternative to address this global issue. However, national rainwater quality standards for both potable and non-potable domestic usages are yet to be established.

As a research collaborator of Project Harvest, we are engaging community members through citizen science about the health of their harvested rainwater, soil, and plants. This project has over 200 participants in four communities throughout the state of Arizona collecting environmental samples over a three-year period. In efforts to encourage water conservation measures at a younger age, we set out to discover just how much the children of Project Harvest participants know about the citizen science work their parents are doing. As a result, the objective of this study was to asses basic knowledge of these topics through illustrations from children who have been exposed to rainwater harvesting directly and indirectly.

## Background

In general, rainwater is relatively free from impurities except those picked up by rain from the atmosphere, but the quality of rainwater may decrease during collection and storage. As a member of the team and an environmental chemist, I evaluate the quality of the rainwater samples using analytical chemistry technologies. Emerging contaminants have been detected globally surface waters for decades. I focus on organic contaminants because most of these pollutants are unregulated, may cause cancer, birth defects, and genetic damage. Some examples of unregulated pollutants include most pesticides and herbicides and industry-wide used chemicals. Three of the communities we work with are rural, legacy mining sites, and quite active with agriculture and farming. The fourth community is urban located near a superfund/contaminated site. Since the harvested rainwater may be used for the irrigation of fruits and vegetables, our future goal is to generate a dataset that informs guidelines and recommendations for safe non-potable use of rainwater while empowering underserved communities in the sustainable production of their own food sources.

## Significance

Water-soluble chemical pollutants or 'emerging contaminants' have been found globally in our drinking water supplies for decades. As these pollutants are emerging, the Environmental Protection Agency does not regulate them and the full risks to human health are not known. Many of these pollutants make their way into our watersheds through the dust: degradation of man-made materials, exhaust from automobiles, airplanes, power plants, agriculture and other plant protection applications, and animal deposition: cattle, birds, etc.

A chemical introduced to the open environment may be transported atmospherically to a nearby water body or it may also rise and settle in cloud formations until it is reintroduced into our rivers and gardens or agricultural fields as rain. The reality is that we are running out of the water and at the same time we are recycling pollutants. Especially now, interests in harvesting rainwater are rising as four billion people worldwide suffer water shortage at least one month a year. Historically, the capturing and storing of rainwater goes back over four thousand years to when we first started to farm the land and needed to find new ways of irrigating crops. In dry climates, collecting rainfall often meant the difference between life and death. With urbanization, the need to conserve water fell away in the last thousand years.

Nowadays, global water shortages return us to this old-fashioned, low technology and critical part of sustainable living. According to the World Health Organization (WHO), 1/3 of the global population suffers from severe water stress, this is expected to double by 2025. Less than five years from now, more than half of the global population will suffer from severe water stress. It is time we learn about the quality of rainwater and start saving for a rainy day by collecting rain for a not so rainy day! This technology can help us combat water shortages by conserving, protecting and maximizing our existing water supply, roof-harvested rainwater can be reused for watering of green spaces, irrigation and with treatment, even drinking!

## Project Design

Project Harvest engages community members through citizen science about the health of their roof-harvested rainwater. Four communities across the state of Arizona were trained in the scientific method and have learned how to measure bacteria, organic, and inorganic contaminants in environmental samples alongside a team of environmental scientists at the University of Arizona. Over a three-year period, participants will collect residential environmental samples from gardens irrigated by roof-harvested rainwater to monitor the quality of roof-harvested rainwater, soil, and plants irrigated by roof-harvested rainwater. My research explores the presence or absence of chemical pollutants in rainwater.

In conjunction with this project, and with the help and support of the CLIMAS fellowship I decided to focus my attention on what children when it comes to rainwater harvesting, water conservation, and quality. Project Harvest is a learning-centered program for citizen scientists that monitors participant knowledge and understanding systematically however surveys are done on the children's learning progress within this project. The objective of this study was to asses basic knowledge of these topics through illustrations from children who have been exposed to rainwater harvesting directly and indirectly.

## Methodology

As a member of Project Harvest, I have the opportunity to work alongside communities across the state of Arizona who regularly practice rainwater harvesting. Rainwater samples collected by citizen scientists across the state of Arizona are sent to the Arizona Laboratory for Emerging Contaminants. Every year, over 800 rainwater samples are received. When the samples arrive at the lab, I prepare them for mass spectrometry analysis. The half-liter of rainwater is concentrated using solid-phase extraction and evaporated to 1 milliliter. This 1 millimeter of the sample is then introduced to the liquid chromatography instrument for separation of the pollutant from the rainwater and finally injected into the mass spectrometer for pollutant detection.

If the pollutant is identified the exact concentration is calculated and the rainwater quality results are shared with Project Harvest families across the state annually during data sharing events where each participant receives personalized data via a physical booklet. At the same time, participant children are encouraged to participate in short rain activities. During this time, children were provided with color pencils and a blank canvass and are asked to illustrate their answers to a few questions that are included below.

- Question 1: Why is it important to harvest rainwater?
- Question 2: How does your family harvest rainwater?
- Question 3: What do you think could be in harvested water, other than water?
- Question 4: How does your family use harvested rainwater?

## Results

The illustrations produced by children aged 9 and 10 were astoundingly consistent. Most of the children had general knowledge when it came to how rainwater is collected, however, when asked about the reason behind this action and the importance of water conservation practices most were unsure. Figure 1 illustrates a typical roof-harvesting collection system that includes gutters, buckets, and a hose. In this illustration, there is no indication of possible sources of rainwater contamination or uses of that harvested rainwater.

Moreover, Figure 2 depicts an atypical rainwater collection system composed of sustainable materials such as clay and bamboo and includes a passive water treatment step in the form of a net. Figure 3 uses the home's roof as a mechanism to direct rainfall onto buckets and includes a sieve to filter out possible contaminants. Question 3 regarding possible sources of rainwater contamination and overall rainwater quality were addressed superficially in Figures 2 and 3 by the presence of passive water treatment methods such as nets and/or sieves. Moreover, Figure 4 sketches understanding both microbial and organic contamination.


*Figure 1. Question 1—How does your family harvest rainwater? From this illustration, it can be seen that rainwater is being collected through a gutter and hose system onto two buckets.*


*Figure 2 Question 1—How does your family harvest rainwater? Question 3—What do you think could be in harvested water, other than water?*


*Figure 3 How does your family harvest rainwater? Question 3—What do you think could be in harvested water, other than water?*


*Figure 4 Question 3: What do you think could be in harvested water, other than water? The sketch above includes both microbial contamination (depicted by bird defecation) and organic contamination by way of automobile exhaust.*

## Discussion

The illustrations produced by children aged  9 and 10 were remarkably consistent. Most of the children in this study could address question 2: How does your family harvest rainwater? and question 3: What do you think could be in harvested water, other than water?  Typical rainwater collection systems included roofs, buckets, cisterns, and gutters. Interestingly enough, there were also drawings that included non-traditional forms of collecting rainwater which included materials such as clay and bamboo. Unfortunately, none of the children that participated could address question 1: Why is it important to harvest rainwater? Three of the children that participated illustrated knowledge of rainwater contamination both microbial and organic as well as basic rainwater treatment in the form of nets and/or sieves.

The microbial contamination was demonstrated by way of bird defecation onto the roof of a home. The organic contamination was depicted by the presence of automobile exhaust rising onto rain clouds. From this study, we have learned that in general, children's knowledge on the topic of water conservation and rainwater contamination is minimal. Furthermore, access to the children of Project Harvest participants was troublesome as annual data-sharing events are attended mainly by adults. Consequently, the participants of this study were not directly exposed to rainwater harvesting at home which has the initial intention of this study.

## Future Work

The goal is to continue assessing the basic knowledge and understanding of water conservation and rainwater harvesting topic through illustrations from children who have been previously exposed to rainwater harvesting either directly (at home) and indirectly (at school). In this study, the participants had been previously exposed to rainwater harvesting indirectly. Therefore, in the future, we hope to (1) increase the number of children participants (2) include a larger age gap (3) as well as expand the number of questions to increase basic water conservation understanding and rainwater uses.