Rainwater Harvesting and Catchment Water Quality

Understanding Catchment Water Quality Testing

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Rainwater harvesting, mostly off roof surfaces, is used all over the world. Some countries, like Australia, have emphasized the benefits of collecting rainwater for personal use because it takes pressure off public water systems during times of dry weather and limited supply. In other countries, like India, groundwater is being depleted and groundwater levels are dropping in many areas. Rainwater harvesting can reduce the need to deepen wells. It also has the advantage of reducing runoff in urban areas and somewhat reducing soil erosion in rural areas.

Here in Hawai‘i rainwater harvesting is also pretty common. Of the sixty thousand people in the state that get their water from catchment systems, most of them are on the Big Island. This means that up to a fourth of Hawai‘i Island residents are on catchment systems, many of them here in Hamakua.

Personal Background

My first exposure to drinking rainwater came during a two-year period when my wife Karen and I were in the Peace Corps in the Marshall Islands. Our house there had a thatch roof and was not suitable for collecting rainwater, but we had access to a 2,000-gallon concrete tank about 150 feet away from our house across the main “road” through the village. It was filled by rainwater collected of the roof of a small store nearby. All our household water was carried from the tank to our house in plastic 5-gallon buckets.

My second exposure to drinking rainwater happened when Karen and I built a home on 15 acres of logged-over land on the Olympic Peninsula in Washington state. A small perennial stream ran right by the house and we tapped into the stream above our house and piped the water to a concrete storage tank that then supplied our household water, including drinking water. We thought the water would be “clean enough” since the watershed for the stream was an uninhabited forested hillside.

So when we moved to Hawai‘i in 1986, onto property for which a water supply from a well or county mains was not possible, we had no qualms about using rainwater off our roof for household use, including for drinking.

Our drinking water supply history may be unusual compared to most people in the US. In the 53 years since graduating from college, before which we only drank water from public water systems, untreated rainwater has been our daily household water for 45 of those years. But as noted above, here on Hawai‘i Island there are many families that have been drinking catchment rainwater for most of their lives.

Water Quality Concerns and Big Island Drink Smart

We have never been careless about the quality of our drinking water. Here in Hawai‘i, we made sure that no rodents could ever get on the roof of our house (which collects our rainwater), kept away trees that could shed leaves or bird feces onto the roof and ensured that all collected water was stored in tanks with solid metal roofs and which excluded any entry by birds and rodents. We raised two kids using this completely untreated water and never had any problems.

It was only after reading about the increased prevalence of rat-lungworm, and noticing the appearance in our neighborhood of the semi-slugs that are the most dangerous vector of the worm larvae, that we decided to filter to our household water supply. We added 5-micron carbon block filters that have been shown to block passage of the larvae.

The addition of filters to our water supply piping had just been completed when I read about a new study to survey county catchment systems for water quality. The Big Island Drink Smart (BIDS) study was funded by the National Science Foundation to determine what factors contribute to drinking water contamination risk in rural communities like ours. One important aspect of the study was to be an in-depth analysis of the water quality of 20 home catchment systems. We applied and were accepted to become one of the homes whose system would be sampled and analyzed for chemical, metal, and bacterial contamination. The water would also be checked for rat lungworm larvae. A detailed description of all the components of our catchment system was also taken.

The partial results of the testing are shown in the table below. Unfortunately, even though the samples of our water were taken a year ago, the tests for chemical contaminants have not been completed. The definitions of the acronyms for drinking water standards are below the table.

For more information on rainwater catchment systems for household and drinking water, see the UH CTARH publication, “Guidelines for Rainwater Catchment Systems” on the PMKCA.org website under “Other Resources”.

	Drinking water standards				Your test results	
	MCL	MCLG	AL	SMCL	tank	sink/faucet
Copper (mg/L)	-	1.3	1.3	1	0.054	0.225
Zinc (mg/L)	-	-	-	5	0.033	0.172
Silver (mg/L)	-	-	-	0.1	ND	ND
Arsenic (mg/L)	0.01	-	-		0.01	0.01
Chromium (ug/L)	100	100	-	-	ND	ND
Lead (mg/L)	-	0	0.015		ND	ND
Aluminum (mg/L)	None	-	-	0.05-0.2	0.056	0.074
Mercury (mg/L)	0.002	0.002	-	-	0.004	0.003
Nickel (ug/L)	average range in US drinking water is 2 - 4.3 ug/L				ND	ND
Cadmium (mg/L)	0.005	-	-		ND	ND
Manganese(mg/L)	-	-	-	0.05	ND	0.001
Iron (mg/L)	-	-	-	0.3	0.035	0.024
Nitrate (mg/L)	10	10	-	-	0.19	
pH	typical range for drinking water 6.5 - 8.5				5.15	
Turbidity (NTU)	1*	-	-	-	0.83 – 0.88	
E. coli (MPN/100 mL)	5%**	0	-	-	0.9 – 1.0	
Total coliform	5%**	0	-	-	73.3 – 93.3	

ND	Not Detected
MCL	Maximum Contaminant Level: The highest level of a contaminant that is allowed in drinking water.
MCLG	Maximum Contaminant Level Goal: The level of the contaminant in drinking water below which there is no known or expected risk to health.
AL	Action Level: The concentration of a contaminant which if exceeded, triggers treatment or other requirements which a water system must follow.
SMCL	Secondary Maximum Contaminant Level: level is for unregulated compounds, which may not be desirable for aesthetic reasons, but are not considered to pose a health risk.
*TT	Treatment Technique. A required process intended to reduce level of contaminant in water. TT =% of samples < 0.3 NTU in at least 95% of measurements taken each month.
**	No more than 5.0% samples total coliform-positive (TC-positive) in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or E. coli if two consecutive TC-positive samples, and one is also positive for E.coli fecal coliforms, system has an acute MCL violation.

My Take on Our Water Quality

One test missing from the table is the test for rat lungworm larvae. That test was made separately but the result was “equivocal”, meaning that there was not enough evidence from the test to say one way or the other. Since the test was on tank water before the carbon block filter and the filters can do final “cleanup” of any larvae, I am not worried at all about rat lungworm.

As shown on the table, toxic metal contamination was below the maximum level allowed except for aluminum and mercury, which both slightly exceeded permitted levels. The

roof of our house is aluminum, as are the gutters, but both are coated with polymer paints, so rainwater has little exposure to aluminum. I know of no source for mercury in any part of our catchment system, so the mercury may be washing out of the air with the rain. Mercury is a common effluent from coal power plants, of which there are many all over the world.

The table indicates that the test results for E. coli and Total Coliform were above US drinking water standards, which allows none of either. Finding out whether these results are cause for concern is not easy. The BIDS team is reluctant to give public health advice because they are not doctors or public health experts. The World Health (WHO) organization has abandoned testing for total coliform, because most coliform bacteria are harmless and a test reveals little about whether pathogenic coliform bacteria are present. From the WHO – "Where community water supplies are unchlorinated, they will inevitably contain large numbers of total coliform bacteria, which may be of limited sanitary significance. It is therefore recommended that the bacteriological classification scheme should be based on thermotolerant (faecal) coliform bacteria or E. coli."

The test for E. coli is far more important, because while most varieties of E. coli are benign (every warm-blooded animal, including humans, has billions of them in their gut), some varieties can cause severe illness. Our results were within recent WHO standards for E. coli, but like health agencies in the US, the current WHO standard is for zero E. coli.

I mentioned earlier that Australia is a country that encourages rainwater harvesting. That country has detailed recommendations about how to go about it, almost all of which our home system follows, but several studies in Australia have revealed the potential of water contamination in rainwater. Even so, the Rainwater Harvesting Association of Australia has noted that "correctly installed rainwater harvesting systems develop a natural treatment train that addresses many of the potential contamination issues that may be associated with a roof catchment. This is an important reason why rainwater harvesting is so widely used in Australia and rainwater users remain healthy. Australian health data indicates drinking untreated rainwater provides health outcomes similar to mains water. One in four households use rainwater harvesting in Australia."

On the other hand, a recent meta-study of rainwater harvesting studies in Australia came to a more cautious conclusion: "In comparison with municipal water supplied to communities, rainwater harvested in Australia can be of poor quality. Contamination with trace metals is generally low, except in some locations with large industry pollution. Contamination with microorganisms is common, but there is limited epidemiological evidence to suggest that exposure to gastrointestinal pathogens in rainwater results in an increase likelihood of gastrointestinal illness. However, there is a need for more research investigating the risk posed by opportunistic pathogens, particularly in susceptible populations. Notwithstanding increasing support to the industry, the Australian Federal Government and all States Health Departments recommend the public to exclusively limit rainwater use for nonpotable purposes to avoid risks of contamination."

In conclusion, while there is little evidence from public health research that drinking rainwater from properly installed catchment and storage systems poses a health risk, health departments in rich countries still do not recommend it. As for my family, we are going to continue drinking our catchment rainwater.