# POTENTIAL CONTAMINANTS IN RESIDENTIAL RAIN BARREL WATER
## (HOME GARDEN SERIES)

Residential gardeners often use rain barrels to collect rainwater from roofs as a supplement to summer irrigation. Rainwater is a natural and unchlorinated water source for aquatic plants and animals. However, rooftop runoff can be contaminated by chemical and biological pollutants from atmospheric deposition, bird droppings, and the roofing material itself. This publication examines the state of knowledge on residential rain barrel water safety in North America over the last 20 years. It also provides science-based recommendations for using rain barrels for irrigation while ensuring that people, pets, and the local environment are protected.

# Importance of Rain Barrels in Reducing Storm Runoff

With the increasing severity of storm events globally, there is great interest in managing stormwater runoff on private and public lands. Rain barrels have repeatedly been found to be effective, low-cost methods of diverting roof runoff for use in landscapes and gardens (Coleman et al. 2018; Li et al. 2021; Li et al. 2019; McClymont et al. 2020; Shin and McCann 2018; Zhang et al. 2016). The use of this low-tech strategy should not be underestimated: researchers have found rain barrels to significantly reduce stormwater runoff (Li et al. 2021), often to a greater extent than other methods such as permeable pavement (Zhang et al. 2016).

In general, rain barrels are viewed favorably by homeowners and often prefer them over raingardens, bioswales, dry ponds, and infiltration trenches, which are more expensive and can be seen as intrusive and even unwelcome design components (Gao et al. 2018). Furthermore, the functional benefits of rain barrels, such as reducing water bills, can be more of a motivating factor for homeowners than the environmental benefits (Gao et al. 2018).

# Rain Barrel Practicality

Unlike other stormwater management methods, rain barrels can be used in any location (Li et al. 2019) and are more practical for smaller properties (Coleman et al. 2018). Rain barrels can help reduce the use of relatively expensive, treated water for nonpotable applications such as watering garden and landscape plants. Alternative nonpotable water sources are increasingly important in chronically or seasonally arid parts of the country. Rain barrels (Figure 1) are relatively inexpensive to obtain and install, and residential installation costs are typically recovered within three to six years (Logan 2014).

Rainwater collected from rooftops has been tested on plants in containers and those planted into gardens and landscapes. In all cases good results have been seen, with no apparent plant disease or disorder problems (Chen et al. 2003; Islam et al. 2013). But rain barrel water is untreated and unregulated. Therefore, there are legitimate safety concerns about exposing people, pets, and the environment to rain barrel water.

Figure 1. A garden rain barrel. Photo: W. McCaleb.

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# What Contaminants Are Found in Rain Barrels?

Many studies have identified rain barrels as reservoirs for toxic materials and pathogenic microbes (Hart and White 2006; Lye 2009; Shuster et al. 2013). Possible rain barrel contaminants fall into two general categories: biological and chemical.

## *Biological Contaminants*

- Bacteria, including fecal coliforms
- Cyanobacteria
- Fungi
- Protozoa

## *Chemical Contaminants*

- Metals, especially heavy metals
- Nutrients
- Particulates (adsorb other chemical contaminants)
- Pesticide residues

Researchers have looked at nutrient loads, heavy metal content, pesticide residues, and microbial contaminants in rainwater collection systems in hundreds of studies worldwide (Table 1). In North America, the main concerns are fecal contaminants and heavy metals.

Table 1. Contaminants identified in international rainwater collection studies from 1996 to 2022.

| **Country** | **Contaminants identified** |
|---|---|
| Africa | heavy metals |
| Australia | heavy metals, mosquitoes, pathogens |
| Bermuda | pathogens |
| China | heavy metals, nutrients, pathogens |
| Finland | pathogens |
| France | heavy metals, nutrients, pathogens |
| Germany | heavy metals |
| Japan | pathogens |
| Korea | heavy metals |
| Netherlands | heavy metals, mosquitoes |
| New Guinea | pathogens |
| New Zealand | copper, microbes |
| Nigeria | heavy metals, pathogens |
| Oman | pathogens |
| Palestine | heavy metals |
| Poland | fertilizers, pesticides |
| Saudi Arabia | heavy metals, pathogens |
| South Africa | microbes |
| South Korea | pathogens |

# Where Do These Contaminants Come From?

Many contaminants, especially chemicals, are carried through the atmosphere and deposited by wind or rain onto roof surfaces. Particulates, heavy metals, and sprayed materials like pesticides are then washed into collector barrels with the next rainfall. Pesticides can remain potent for weeks or months after entering rain barrels (McDougall et al. 1994).

Biological materials drop from tree canopies or are deposited directly by birds, squirrels, raccoons, and other animals that perch or crawl over roofs. Feces are a source of pathogenic bacteria, viruses, and protozoans that can easily survive in rain barrels. A long-term study on residential rain barrels (Shuster et al. 2013) found unexpectedly high levels of coliform bacteria (used as indicators of human pathogenic bacteria). The water in the study's barrels was consistently above US EPA standards for coliform bacteria in secondary recreational contact water quality (Shuster et al. 2013).

Although the levels of coliform bacteria are alarmingly high in studies like Shuster et al. (2013), there do not appear to be many reports of illnesses related to rain barrel water. The authors also discovered that rain barrels contain a rich microbial community that may contain predators that feed on harmful bacteria, which may control the levels of coliform bacteria (Shuster et al. 2013).

# Do Roofs Themselves Affect Rainwater Quality?

Metal flashing, gutters, and galvanized nails are sources of heavy metals like zinc, lead, and chromium. In addition, composite shingles, roofing membranes, and tar paper contribute to organic contaminants, heavy metals, and pesticides in roof runoff. Consequently, much research has focused on roof characteristics (de Kwaadsteniet et al. 2013).

## *Slope*

The greater the slope, the less likely contaminants will remain on the surface simply because it takes less rainfall to run off a sloping roof, resulting in contaminants washing off the roof more frequently.

## *Chemical Makeup*

Metal roofs have lower concentrations of biological contaminants (Mendez et al. 2011) but higher levels of cadmium and zinc (van Metre and Mahler 2003). Asphalt shingles contain lead (van Metre and Mahler 2003). Green roofs can contain high levels of arsenic and other heavy metals from the growth media (Mendez et al. 2011). Wood shingles appear to be the worst in terms of their effect on water quality (Chang et al. 2004).

## *Surface Roughness*

Rough materials like asphalt catch and retain wind-deposited particulates and fecal matter (Shuster et al. 2013).

## *Surface Coating*

Moss-inhibiting pesticides are often applied to roofing materials before installation (Bucheli et al. 1998).

## *Age*

Newer wood-shingled roofs contain more zinc than aged roofs (Chang et al. 2004).

## *Maintenance History*

Moss treatments typically contain zinc or copper, which are significant contaminants in rain barrels.

# Action Items for Gardeners Using Roof-Collected Rain Barrel Water

Rain barrels can be a valuable source of additional water for home gardens and landscapes. In addition, there are some simple, research-based practices gardeners can use to take advantage of collected rainwater that reduce the risks of contamination exposure.

## *Know Your Local Pollution Issues*

If there is a history of airborne pollutants from industry or agriculture in your area, you will want to have your rain barrel water tested for heavy metals and other contaminants.

## *Avoid Collecting Rainwater in the Following Scenarios*

- When air quality is low (smoggy, temperature inversions, low wind speeds).
- If you have recently used a moss removal product on the roof.
- If pesticides have been recently applied nearby.

## *Use Good Garden Hygiene*

- Keep barrels tightly sealed to prevent mosquito breeding. If sealing the barrel is impossible, consider adding a larvicide (Ibañez-Justicia et al. 2018) approved for homeowner use. Larvicides are pesticides and must be labeled for rain barrel use. Label instructions must be followed.
- Do not drink rain barrel water or allow pets to drink it.
- Do not touch your eyes or mouth when handling rain barrel water.
- Wash hands with soap after using rain barrel water.
- Clean rain barrels regularly to remove residual contamination. Directions for cleaning rain barrels can be found online from commercial vendors of barrels.

## *Wash Garden Produce before Eating*

Unwashed leafy greens pose the highest health risk, followed by botanical fruits such as tomatoes and cucumbers (Lim and Jiang 2013).

## *Install a Diverter*

Install a diverter to direct the first flush of rainwater runoff onto lawns or rain gardens and away from collector barrels (Figure 2). The first flush of harvested rain has the highest level of contaminants, as it moves deposited material off the roof and into the gutters.


Figure 2. A diverter for protecting water quality in the barrel. Photo: M.J. Pilgrim.

## *Prevent Roof Debris from Entering the Rain Barrels*

Prevent roof debris from entering the rain barrels using leaf screens or other gutter covers (Figure 3). Debris is a source of chemical contamination and a nutrient source for bacteria and other microbes.

## *Buy Simple Coliform Counters*

Buy simple coliform counters or Petrifilms to test for fecal contaminants (Figure 4). These are available from science supply houses and can alert you to the need for further professional testing.

## *Use Activated Charcoal Filters*

Use activated charcoal filters to treat water before use on vegetables and other edible plants (Figure 5). These filters can remove sediments, organic contaminants, and some mineral contaminants from water, but will not remove heavy metals.

Figure 3. Gutter guards prevent the accumulation of biological debris in the gutters and rain barrels. Photo: D.Y. Leggett.

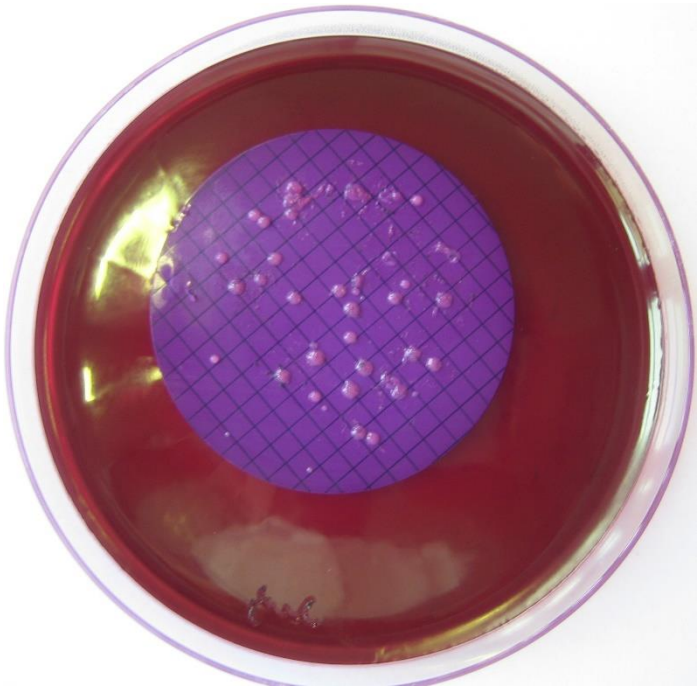

Figure 4. A coliform counter disk. Photo: M. Matthias (CC BY-SA 3.0).

## *Use Opaque Barrels*

Use opaque barrels to eliminate photosynthetic pathogens such as cyanobacteria.

Figure 5. A filtering pitcher can be used to treat rain barrel water before application. Photo: Smial (CC BY-SA 2.0 DE).

# Further Reading

Centers for Disease Control and Prevention. Rainwater Collection.

Federal Energy Management Program. Rainwater Harvesting Regulations Map. This map provides information on how rainwater harvesting is regulated across the US to help gardeners determine whether they can legally collect rainwater in rain barrels.

Washington State Department of Ecology. Roofing Materials Assessment. The Department of Ecology has conducted research on the quality of runoff associated with different roof materials.

Washington State Department of Ecology. Rainwater Collection in Washington State. The Department of Ecology maintains a website that discusses the practical and legal considerations of installing a residential rainwater collection system.

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