

Rooftop Rainwater Harvesting for Plant Irrigation II: Water Quality and Horticultural Considerations

Fact Sheet FS1165

Cooperative Extension

Salvatore S. Mangiafico, Environmental and Resource Management Agent
Christopher C. Obropta, Extension Specialist in Water Resources

Rainwater harvesting at privately owned businesses and farms is primarily used for reducing runoff during rain events and to conserve potable water resources. Collected water is often used for supplemental ornamental plant irrigation, for which purpose it is generally suitable. While most collected rainwater could be treated and disinfected to make it of potable quality, in New Jersey collected rainwater typically cannot be used legally in public or non-public water systems (NJDEP 2004b). This publication does not address all the considerations that would be necessary for using harvest rainwater as a potable water source.

Potential Contaminants in Harvested Rain Water

In general, rainwater is a relatively pure source of water when compared with surface water, reclaimed water, or, in some cases, groundwater. However, it should be noted that harvested rainwater will contain a variety of constituents that may be considered contaminants. The rain itself may pick up a variety of contaminants suspended in the air, and may also carry away substances deposited on the roof and collecting surfaces during dry weather.

Additional contaminants can come from the materials of the collecting surfaces themselves, or come from animal droppings or plant debris on the collecting surfaces. Also, algacides or waterproofing materials added to roofing materials may leach into collected water. Some contaminants could be considered natural, while others are clearly human-contributed. While some contaminants are deposited from the atmosphere from wet or dry deposition, other contaminants may be released from the materials used for the collection equipment. Deposition onto collection surfaces, though, is probably the largest factor in influencing what contaminants will be found in collected water. Contaminants found in harvested rain water will likely be influenced by the surrounding area. In agricultural areas, soil particles and pesticides

may be present, whereas in urban areas heavy metals and hydrocarbons from industry or vehicle traffic may be present. The amounts of contaminants will also vary based on weather patterns, since contaminants can build up on roof surfaces during dry weather, and then be found in high concentrations during the beginning of the next rain, an effect known as "first flush."

Consideration should also be given to the materials used in the roof and water collection system. While polyvinyl chloride (PVC), aluminum, and galvanized steel surfaces contribute few pollutants themselves, glues, sealants, or lead solder can contribute contaminants to collected water (Texas Water Development Board 2005). Metal surfaces may contribute metals; for example, water in contact with galvanized materials may leach out zinc. Typical composite or asphalt shingles may leach other compounds. Potential contaminants of most concern include heavy metals (such as zinc, copper, lead, cadmium, and chromium), polycyclic aromatic hydrocarbons (PAHs), pesticides, and pathogenic bacteria (Clark et al. 2008, DeBusk et al. 2009, Lye 2009).

Because each of these contaminant categories have chemicals with known health effects to humans, drinking untreated harvested rain without further treatment is not recommended. Common sense sanitation measures, such as washing hands after handling collected water, should also be followed.

Each of these contaminant categories has chemicals with potential toxicity in environmental systems, particularly aquatic environments. Considering this, it may be a better conservation practice to collect roof runoff and use it on-site rather than allow any potential contaminants to move into the local stormwater system. Many contaminants will preferentially associate chemically with particles and organic matter; therefore, separating out any particles from collected water before use or discharge may be beneficial.

Water Quality For Irrigation

Even though harvested rainwater may have elevated concentrations of certain contaminants, the general chemical properties of rainwater in New Jersey will be acceptable for plant irrigation. Recommendations for crop specific water quality should be followed when available. Irrigation water should have suitable chemical parameters, including pH, alkalinity, salts, and concentrations of specific elements (Cabrera 1998). Rainwater in New Jersey is typically acidic, with annual averages ranging from 4.3 to 4.9 pH units (NADP no date). Electrical conductivity is typically below 0.1 mmhos/cm (0.1 dS/m), and concentrations of specific ions are typically relatively low (NADP no date).

Specific water quality parameters are important in ensuring water will not clog drip emitters or sprinklers with fine nozzles. These include water hardness, suspended solids, bacteria, and specific metal concentrations (Storlie 1995). In general, harvested rainwater should not be problematic for these applications. Typically, hardness of rainwater will not exceed recommended levels. Suspended solids and bacteria can be controlled with proper collection design and maintenance.

Depending particularly on the materials used in the water collector, harvested water may have elevated levels of certain metals which might contribute to clogging of irrigation emitters, such as iron and manganese. Filtration of water may be necessary if it contains particulates that could clog irrigation systems. Similarly, iron, manganese, and bacteria could be removed with a combination of filtration and water treatment if necessary.

Edible Crops

Because harvested rainwater may have elevated concentrations of a variety of contaminants, caution should be used in using it for edible crops. It is safer to use harvested water for ornamental plants that will not be eaten. For edible crops, where possible, water should be applied to soils rather than to the edible parts of plants. In the soil, many contaminants including metals may become bound to soil particles and organic matter, making them less available for plant uptake or runoff.

Safety and Hygiene

Whenever handling harvested rainwater, basic good hygiene practices should be followed. Wash hands after handling water, or preferably wear impermeable gloves. Avoid getting harvested water into eyes, mouth, or open wounds.

Potential For Heavy Metal Contamination of Soils

Because of potential elevated levels of metals such as copper or lead in roof runoff, it is possible over the long term to load soils with metals to the point where they may be of concern for plant health. Recommended limits for applying water with significant heavy metal concentrations are expressed in two ways. One approach is to evaluate the concentrations of metals in the water itself. USEPA (2004, Table 2-7) follows this approach, basing recommended limits on typical amounts of water applied to plants and chemistry of the metal ions in soil. Limits for select metals are given in Table 1.

Table 1. Recommended maximum concentrations of selected metals in irrigation water to prevent plant toxicity.*

Constituent	Symbol	Maximum level in water (mg/L) [†]
Cadmium	Cd	0.01
Copper	Cu	0.2
Lead	Pb	5.0
Zinc	Zn	2.0

*Adapted from USEPA 2004, Table 2-7. A longer list of constituents can be found there. Concentrations are based on 20 years of use in soils. Higher concentrations may be permissible for shorter term use.

[†]Toxicity will vary by plant species, and environmental concern will vary by constituent and soil properties.

A second approach is to evaluate the concentration of a metal in the soil. It is important to note that the metal concentration in the soil may be reported as either the *total* or *available* concentration. The *total concentration* is where virtually all of the metal is extracted from the soil and reported. The total concentration generally exceeds what a plant can remove from the soil. The *available concentration* is an estimate of the amount of metal in the soil which would be available for plant uptake. Table 2 lists regulatory limits for total concentration of some metals for land application and also cautionary limits for plant health of available metals.

Comparing data from studies of roof runoff concentrations of metals in the U.S. (Clark et al. 2008, DeBusk et al. 2009) to recommended maximum concentrations in water (USEPA 2004), both copper and zinc in roof runoff were sometimes recorded at concentrations that could lead to phytotoxic soil concentrations in some cases. Clark et al. (2008) suggested that zinc concentrations may be particularly high from roofs made of galvanized metal or

aluminum-zinc-coated materials, and that copper concentrations may be particularly high from wood products which use copper compounds as preservatives.

Lead concentrations reported by Clark et al. (2008) and DeBusk et al. (2009) for roof runoff in the U.S. ranged from non-detectable to 0.3 mg/L. Considering this range, soils would probably have to be irrigated for decades to build up lead concentrations greater than those considered “background levels” for children’s health for New Jersey soils (greater than 100 mg/kg total lead) (Hamel et al. 2010). However, since the results of this calculation will depend on the actual irrigation rate and soil properties, prudence suggests soil should be tested periodically when applied water has lead concentrations in the tenths of mg/L, if there is concern of exposure to lead-contaminated soils.

Commercial or university laboratories can determine the concentration of metals in collected water and soil. Be sure to know whether the soil test will measure total concentrations of metals or available concentrations of metals. Available copper and zinc concentrations are included as part of a standard soil fertility test by the Rutgers Soil Testing Laboratory (njaes.rutgers.edu/soiltestinglab/); a test for available lead is also available there (Hamel et al. 2010).

Where elevated levels of zinc or copper in soil are suspected, plant health can be promoted by liming the soil to correct pH, maintaining optimum phosphorus levels in the soil, and adding compost or other organic matter to soils with low organic matter (Rutgers Soil Testing Laboratory no date b). Recommendations from soil tests should be followed. A similar approach

could be followed in the case of suspected elevated concentrations of lead, though additional precautions may be warranted if children are in contact with the soil in these cases (Hamel et al. 2010).

Summary

In most cases, water collected from the roofs of buildings should be acceptable for use in irrigating ornamental plants. Rain water in New Jersey tends to have chemical qualities that make it acceptable to use for irrigation. However, roof runoff may contain a variety of impurities deposited on the roof during dry times or carried in the rain itself. Small amounts of most common impurities are unlikely to be a concern. However, in some cases the water may have elevated concentrations of metals either deposited from the atmosphere or leached from materials in the roof or water collection system. Additionally, it should be kept in mind that roof runoff may have animal dropping or other organic debris that can carry bacteria.

Employing a device that diverts away the first flush of roof runoff—which is likely to contain the bulk of impurities collected on the roof during dry times—can reduce the amount of pollutants in collected water. Similarly, prudence suggests using good personal hygiene when handling collected water. If there are pollutants of concern in water, application to ornamental rather than edible crops is recommended. If edible crops are irrigated with collected water, applying water to the soil may be preferable to applying it to the edible portions of plants.

Table 2. Recommended maximum concentrations of selected metals in soil.

Constituent	Symbol	Maximum <i>total</i> concentration in soil (mg/kg or ppm total) *	Cautionary <i>available</i> concentration in soil (mg/kg or ppm available) †
Cadmium	Cd	13	—‡
Copper	Cu	500	20
Lead	Pb	140	—
Zinc	Zn	900	50

* Figures are for total concentrations in soil. Based on U.S. regulatory limits for land application of sludge and wastes. Adapted from NRCS (2000), using the rough conversion: kg/ha = mg/kg x 3. A longer list of constituents can be found there.

† Based on cautionary limits for plant health. Figures are for available metal concentrations by Melich extractant. Adapted from Rutgers Soil Testing Laboratory (no date a).

‡ Data not available.

References

- Cabrera, R. 1998 Evaluating Water Quality for Ornamental Plant Production, FS893. New Brunswick, NJ: Rutgers NJAES Cooperative Extension, njaes.rutgers.edu/pubs/publication.asp?pid=FS893.
- Clark, S.E., K.A. Steele, J. Spicher, C.Y.S. Siu, M.M. Lalor, R. Pitt, & J.T. Kirby. 2008 Roofing Materials' Contributions to Storm-Water Runoff Pollution. *Journal of Irrigation and Drainage Engineering* 134: 638–645. doi: 10.1061/(ASCE)0733-9437(2008)134:5(638).
- DeBusk, K.M., W.F. Hunt, D.L. Osmond, & G.W. Cope. 2009 Water Quality of Rooftop Runoff: Implications for Residential Water Harvesting Systems. Raleigh, NC: North Carolina Cooperative Extension, bae.ncsu.edu/stormwater/PublicationFiles/RooftopRunoff2009.pdf.
- Hamel, S., J. Heckman, & S. Murphy. 2010 Lead Contaminated Soil: Minimizing Health Risks, FS336. New Brunswick, NJ: Rutgers NJAES Cooperative Extension, njaes.rutgers.edu/pubs/publication.asp?pid=FS336.
- Lye, D.J. 2009 Rooftop runoff as a source of contamination: A review. *Science of the Total Environment* 407: 5429–5434. doi:10.1016/j.scitotenv.2009.07.011.
- (NADP) National Atmospheric Deposition Program. No date. National Atmospheric Deposition Program, nadp.sws.uiuc.edu/Default.aspx.
- (NRCS) Natural Resources Conservation Service. 2000 Heavy Metal Soil Contamination. Auburn, AL: Natural Resources Conservation Service Soil Quality Institute, soils.usda.gov/sqi/management/files/sq_uhn_3.pdf.
- (NJDEP) New Jersey Department of Environmental Protection. 2004b Safe Drinking Water Act Regulations (N.J.A.C. 7:10). Trenton, NJ: New Jersey Department of Environmental Protection, state.nj.us/dep/watersupply/sdwarule.pdf.
- Rutgers Soil Testing Laboratory. No date a. Table of Relative Levels of Nutrients. New Brunswick, NJ: Rutgers NJAES Cooperative Extension, njaes.rutgers.edu/soiltestinglab/pdfs/rellev.pdf.
- Rutgers Soil Testing Laboratory. No date b. Interpretive Statements for Micronutrients. New Brunswick, NJ: Rutgers NJAES Cooperative Extension, njaes.rutgers.edu/soiltestinglab/pdfs/micronutrient-statements.pdf.
- Storlie, C. 1995 Using Irrigation Water Tests to Predict and Prevent Clogging of Drip Irrigation Systems, FS793. New Brunswick, NJ: Rutgers NJAES Cooperative Extension, njaes.rutgers.edu/pubs/publication.asp?pid=FS793.
- Texas Water Development Board. 2005 The Texas Manual on Rainwater Harvesting. Austin, TX: Texas Water Development Board, twdb.state.tx.us/publications/reports/rainwaterharvestingmanual_3rdedition.pdf.
- (USEPA) United States Environmental Protection Agency. 2004 Guidelines for water reuse, EPA/625/R-04/108. Washington, DC: United States Environmental Protection Agency, Office of Water, epa.gov/nrmrl/pubs/625r04108/625r04108.pdf.

© 2011 Rutgers, The State University of New Jersey. All rights reserved.

For a comprehensive list of our publications visit www.njaes.rutgers.edu

July 2011

Cooperating Agencies: Rutgers, The State University of New Jersey, U.S. Department of Agriculture, and County Boards of Chosen Freeholders. Rutgers Cooperative Extension, a unit of the Rutgers New Jersey Agricultural Experiment Station, is an equal opportunity program provider and employer.