Microbial Treatment Through a Rainwater Harvesting System Designed to the ARCSA/ASPE/ANSI Standard 63

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Introduction:

ARCSA/ASPE/ANSI Standard 63 is a Plumbing Engineering and Design Standard for Rainwater Catchment Systems that supports a four-step process to encourage natural biofilms as part of the water filtration and treatment. This four-step process is not found in any other national or global standard and sets Standard 63 above all other processes to create the cleanest water possible in a rainwater harvesting system. This document sets out to estimate the effectiveness of ARCSA/ASPE/ANSI Standard 63 in reducing microbial concentrations in supplied rainwater by calculating log reduction values for the system components. The estimates are based on a literature survey of peer reviewed articles to evaluate the potential log reduction values associated with the four-step process in supplied rainwater.

The four steps include prefiltration, a smoothing inlet, a floating filter intake, and a skimming overflow. The prefiltration step removes large particulate matter, which carries and feeds bacteria. It also oxygenates the water in the tank, greatly reducing the number of harmful bacteria in the tank. The smoothing or calming inlet is designed to direct the incoming water upwards to prevent disturbance of the biofilm that has settled to the bottom of the tank. The biofilm at the bottom, and some found on the walls of the tank, work to eliminate bad bacteria, therefore creating a healthier water environment. The floating filter draws water out of the tank below the surface of the water to avoid any floating particulate. This ensures water is drawn where the cleanest water in the tank is found. The skimming overflow removes the floating particulate off the surface of the water while also providing an excess water overflow. This overflow should also eliminate vectors and vermin as well as backflow from any storm drains.

There are additional cleansing processes that occur in the tank with biofilms, and there are multiple studies on these processes. However, there are no definitive results from these studies, and additional research is needed to determine how these four steps combined work to affect biofilms in stored rainwater. This study only analyzed the four-step process found in Standard 63 as it relates to log reductions and water quality in supplied rainwater. The post filtration processes typically include proven filters and disinfection treatment trains and equipment that have been assigned proven log reduction levels. There has never been a log reduction assigned to the Standard 63 four-step process, though this project argues that the four-step process does provide log reduction values and should be recognized as a valid treatment method for rainwater catchment systems.

There is additional research needed that analyzes rainwater runoff from various roof surfaces and the four-step process in Standard 63. Those aspects still need assigned a level of participation in creating high water quality, but those aspects will vary greatly by rainfall quantity, rainfall timing, system location, and catchment surface. Part of the process is the time between rainfall events when everything dies in the tank and settles to the bottom of the tank. That is when the cleanest water is found in a tank. There are two zones in a tank - the top aerobic, where we pump water from and the bottom 6-inch anaerobic zone, that we try not to disturb when new water is added to a tank. This paper evaluates the literature available for the elements in the four-step process while knowing there are many other factors that contribute to the water quality in a Standard 63 rainwater catchment system.

It is ARCSA International's primary goal to assign a minimum of a two-log reduction to the ARCSA/ASPE/ANSI Standard 63 rainwater harvesting system design involving the four-step process for bacterial reduction based on the following literature review and the additional knowledge that natural processes found in a well-designed rainwater tank only add to the high-water quality. Currently, the post tank filtration and purification steps required by Standard 63 will eliminate viruses and protozoa. However, log reduction tables typically show zero log reduction targets for viruses and a 1-1.5 log reduction target for protozoa (per DALY and California respectively) contaminants which will additionally be eliminated in the post tank filtration and purification.

Microbial treatment from pre-tank and in-tank processes required by Standard 63

Purpose: The goal of this project was to estimate the effectiveness of ARCSA/ASPE/ANSI Standard 63 in reducing microbial concentrations in supplied rainwater relative to direct roof runoff by calculating log reduction values for the required system components. This project focused on pre-tank and in-tank components of rainwater harvesting system design. The components include pre-tank filtration, optional diversion of the first flush of rainwater, a calming inlet and floating filter, which encourage settling and biofilm development in the tank, and a protected overflow device.

Approach: The estimates in this study are based on a literature survey. Journal articles were collected using Randolph College's OneSearch from EBSCO. The search terms and the number of articles found with these search terms are included in Table 1. In many cases, papers were found using multiple search terms, making the total number of papers reviewed for this project lower than the sum of the number of papers found with the search terms.

Search terms	# of papers found
rainwater and harvest* and filt*	145
rainwater and harvest* and debris exclu*	0
rainwater and harvest* and biofilm	19
rainwater and harvest* and settling	1
rainwater and harvest* and first flush	46

Table 1: Search terms used to find journal articles for this analysis and the number of papers found for each set of terms.

To calculate a log reduction value, two estimates of microbial concentrations were needed – an estimate of the concentration without the system component and an estimate of the concentration with treatment by the system component. For standard post-tank water treatment components, such as ultraviolet lights, these two measurements are typically taken before and after the treatment component. The log reduction is then calculated as

$$\text{Log reduction} = \log_{10}\left(\frac{Concentration\ before\ treatment}{Concentration\ after\ treatment}\right)$$

Based on this, for inclusion in this analysis, a research paper needed to provide paired measurements of concentration with and without the system component. These paired measurements could either be measurements at two points within the same system (e.g. before the storage tank and after the storage tank) or measurements from paired systems, one with the component and one without (e.g. measurements of bacterial concentration in the storage tank of a rainwater harvesting system with a pre-tank filter and measurement of bacterial concentration in the storage tank of an adjacent rainwater harvesting system without a pre-tank filter). In addition, only papers from peer-reviewed publications were included and papers studying post-tank treatment only were excluded. Conference papers were not included. Out of all of the papers reviewed for this project, 15 papers included data that could be used to calculate log reduction values, 185 papers were not suitable for calculating log reduction values.

Findings: All of the log reduction values calculated are included in Appendix A. A list of the excluded papers, including a brief note of the reason for exclusion is included in Appendix B.

A summary of the findings, showing mean log reductions by component is shown in Table 2.

Rainwater harvesting system component	*E. coli*	Fecal coliforms	Total coliforms	Other bacteria*
Pre-tank filter and first flush	0.1	0.1	0.1	
Pre-tank filter			0.5	
First flush**	1.2	0.4	0.5	1.1
In-tank processes***	1.1	0.2	0.3	0.8
Overflow**	1.7		1.0	1.5
Full system - no post-tank treatment	0.5	0.8	1.0	

Table 2. Mean log reduction values calculated for different pre-tank and in-tank rainwater harvesting system components.
*This category includes data on heterotrophic plate count, viable count at 30℃, Pseudomonas, Enterococcus and thermotolerant coliforms. These types of bacteria were studied less frequently and are pooled for ease of analysis. These bacterial groups would not necessarily be expected to respond similarly to treatment. However, because the treatment studied here is largely mechanical, the treatment efficacy on these different groups of different parts of the rainwater harvesting system are likely small. All of the individual data points are available in Appendix A.
** This value is likely an overestimate of the impact of the first flush and overflow. See details below.
*** In-tank processes includes the biofilm, floating filter, and settling

Pre-tank filtration and first flush - Pre-tank filtration, which is required in Standard 63, has received very little research attention. Two studies (Costa *et al,* 2021, Taffere *et al,* 2017) examined novel pre-tank filters, designed specifically for the study. No log reduction

value could be calculated from the Costa *et al* (2021) study because the initial bacterial concentrations were below the limit of detection. A single study (Amin *et al*, 2013) examined the impact of a combined first flush and pre-tank filter system and found modest log reductions. This leaves the impact of pre-tank filtration on the quality of harvested rainwater largely unstudied.
Diversion of the first flush is an optional feature of rainwater harvesting systems designed in accordance with Standard 63. However, it is included here because of the research attention given to the first flush.The estimates of log reductions due to first flush diversion (based on Gikas and Tsihrintzis, 2012; Gikas and Tsihrintzis, 2017; Lee *et al,* 2011; Mendez *et al,* 2011; Morgoda *et al,* 2022; Sambas *et al,* 2019; van der Sterren *et al,* 2023) are calculated by comparing the water quality in the first flush water to stored water in the tank. This is certainly an overestimation because the first flush water would be diluted in the tank. These values are included in the table because of the emphasis the first flush has received in the research literature, but should not be considered a true estimate of the impact of first flush diversion.

In-tank processes - In-tank processes can be measured by comparing the water quality at an elevated uptake point to water quality lower in the tank, mimicking the ability of a floating filter to take cleaner water as settling occurs or by measuring the water entering the storage tank and as it is pumped from the storage tank. Log reduction values for these processes range from 0.2 - 1.1 for the different bacterial components studied, with a median of 0.8 (based on Amin *et al,* 2013; Andriamanantena *et al,* 2021; Kim and Han, 2014; Kim and Han, 2015; Tran *et al,* 2021; var der Merwe, 2013).

Overflow - A single study (van der Sterren *et al*, 2013) compared the concentration of microbial contaminants in an overflow tank with the concentration in the main rainwater harvesting storage tank. Similar to the challenges of estimating the impacts of the first flush, this compares the concentration of a contaminant in a small volume removed from a much larger tank to the concentration in the larger tank. If all of the overflow water (or the first flush water) was added to the larger storage tank, the impact on the concentration of the microbial contaminant in the storage tank would not be as large as implied by a log reduction value calculated just comparing these concentrations because of dilution.

Full system - A single study also examined the water quality benefits of a full system, including first flush diversion, pre-tank filtering and in-tank processes, without including post-tank treatment (Amin *et al*, 2013). For the bacterial components measured, the log reduction ranged from 0.5-1.2, depending on the bacterial component considered. Other studies (Barriga *et al*, 2024; Khalid and Alodah, 2023) provide information on the log reduction of a full rainwater harvesting system, including post-tank treatment, but these studies were not included in the table

Limitations: Much of the research literature on rainwater harvesting still focuses on identification of microbial contamination in rainwater harvesting tanks, with little emphasis on the impacts of treatment. Typically, when treatment is considered, researchers study post-tank treatment or first-flush diversion. The limitations of many of these studies on first-flush diversion are discussed below.

Virtually all of the research on viruses in rainwater harvesting systems uses molecular techniques to identify the viruses. These techniques identify the genetic material of the virus, and therefore will detect both active and inactive viruses. Because of this, only physical removal of viruses, through settling, diversion or filtration can be measured. In addition, few of the studies quantify the viral load.

A further limitation is that viruses and protozoa in rainwater harvesting systems are relatively understudied compared to bacteria, particularly bacterial indicator organisms such as total coliforms. This literature survey did not discover any studies that measure either of these contaminants at multiple points in a single rainwater harvesting system, except those that measure post-tank treatment.

The literature surveyed also did not include any studies that feature a controlled comparison of a rainwater harvesting system (or multiple systems) designed with components included in Standard 63 and a system (or systems) without those components.

Finally, many of the water quality benefits of appropriate rainwater harvesting design are based on in-tank processes that reduce the microbial contamination through settling and death/inactivation. For example, preventing organic debris from entering the storage tank reduces the nutrient load available for bacteria. These processes contribute to overall improvement of the water quality in rainwater harvesting tanks; however, without paired studies of rainwater harvesting systems with and without appropriate design, the impact of these features is difficult to determine.

Conclusion: In summary, the research literature does not provide sufficient evidence to ascribe a log reduction value for appropriately designed rainwater harvesting systems for viruses or protozoa. However, the research on rainwater harvesting systems demonstrates that the pre-tank and in-tank components of a rainwater harvesting system effectively reduce bacterial concentrations and a log reduction value between 1 and 2 is appropriate for these systems.

References:

Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329

Andriamanantena R., V., Kim, M., & Han, M. (2021). Effect of Visible Light on Surface-Attached and Suspended Heterotrophic Bacteria in a Typical Household Rainwater Harvesting Tank. Sustainability, 13(10), 5410-. https://doi.org/10.3390/su13105410

Barriga, F., Gómez, G., Diez, M. C., Fernandez, L., & Vidal, G. (2024). Influence of Catchment Surface Material on Quality of Harvested Rainwater. Sustainability, 16(15), 6586-. https://doi.org/10.3390/su16156586

Costa, P. C. L. da, Azevedo, A. R. G. de, Silva, F. C. da, Cecchin, D., & Carmo, D. de F. do. (2021). Rainwater treatment using an acrylic blanket as a filtering media. Journal of Cleaner Production, 303, 126964-. https://doi.org/10.1016/j.jclepro.2021.126964

Gikas, G. D., & Tsihrintzis, V. A. (2012). Assessment of water quality of first-flush roof runoff and harvested rainwater. Journal of Hydrology, 466, 115-126.

Gikas, G. D., & Tsihrintzis, V. A. (2017). Effect of first-flush device, roofing material, and antecedent dry days on water quality of harvested rainwater. Environmental Science and Pollution Research, 24, 21997-22006.

Khalid, B., & Alodah, A. (2023). Multivariate Analysis of Harvested Rainwater Quality Utilizing Sustainable Solar-Energy-Driven Water Treatment. Sustainability, 15(19), 14568-. https://doi.org/10.3390/su151914568

Kim, M., & Han, M. (2014). Characteristics of biofilm development in an operating rainwater storage tank. Environmental earth sciences, 72, 1633-1642.

Lee, J. Y., Kim, H. J., & Han, M. Y. (2011). Quality assessment of rooftop runoff and harvested rainwater from a building catchment. Water Science and Technology, 63(11), 2725-2731.

Mendez, C. B., Klenzendorf, J. B., Afshar, B. R., Simmons, M. T., Barrett, M. E., Kinney, K. A., & Kirisits, M. J. (2011). The effect of roofing material on the quality of harvested rainwater. Water Research (Oxford), 45(5), 2049–2059. https://doi.org/10.1016/j.watres.2010.12.015

Morgado, M. E., Hudson, C. L., Chattopadhyay, S., Ta, K., East, C., Purser, N., Allard, S., Ferrier, M. D., Sapkota, A. R., Sharma, M., & Goldstein, R. R. (2022). The effect of a first flush rainwater harvesting and subsurface irrigation system on E. coli and pathogen concentrations in irrigation water, soil, and produce. The Science of the Total Environment, 843, 156976–156976. https://doi.org/10.1016/j.scitotenv.2022.156976

Sambas, N. F. B., Baloo, L., & Mustaffa, A. P. Z. (2019). Rainwater harvesting with subsequent first flush: Water quality performance for non-potable purpose. International Journal of Recent Technology and Engineering, 8(2 Spec), 76-79.

Tran, S. H., Dang, H. T. T., Dao, D. A., Nguyen, V.-A., Nguyen, L. T., & Han, M. (2021). On-site rainwater harvesting and treatment for drinking water supply: assessment of cost and technical issues. Environmental Science and Pollution Research International, 28(10), 11928–11941. https://doi.org/10.1007/s11356-020-07977-0

van der Merwe, V., Duvenage, S., & Korsten, L. (2013). Comparison of biofilm formation and water quality when water from different sources was stored in large commercial water storage tanks. Journal of water and health, 11(1), 30–40. https://doi.org/10.2166/wh.2012.014

van der Sterren, M., Rahman, A., & Dennis, G. R. (2013). Quality and Quantity Monitoring of Five Rainwater Tanks in Western

Sydney, Australia. Journal of Environmental Engineering (New York, N.Y.), 139(3), 332–340. https://doi.org/10.1061/(ASCE)EE.1943-7870.0000614

Appendix A: Calculated log reduction values for rainwater harvesting system components

Rainwater harvesting system component	Water quality constituent	Log reduction	Reference	Notes
First flush	*E. coli*	0.4	Lee, J. Y., Kim, H. J., & Han, M. Y. (2011). Quality assessment of rooftop runoff and harvested rainwater from a building catchment. Water Science and Technology, 63(11), 2725-2731.	This is likely an overestimate - this compares the concentration at 5 minutes after the start of the rain (identified as the highest turbidity) with stored water quality -- the stored water quality was typically worse than the water quality after 100 min of runoff (collected directly from the roof). Data was estimated from figure 3.
First flush	*E. coli*	0.6	Morgado, M. E., Hudson, C. L., Chattopadhyay, S., Ta, K., East, C., Purser, N., Allard, S., Ferrier, M. D., Sapkota, A. R., Sharma, M., & Goldstein, R. R. (2022). The effect of a first flush rainwater harvesting and subsurface irrigation system on E. coli and pathogen concentrations in irrigation water, soil, and produce. The Science of the Total Environment, 843, 156976–156976. https://doi.org/10.1016/j.scitotenv.2022.156976	This value represents a comparison of first flush water quality with "irrigation water" quality at site RC. Site HC was not included because the irrigation water was sampled from observation wells after influence from soil
First flush	*E. coli*	2.5	van der Sterren, M., Rahman, A., & Dennis, G. R. (2013). Quality and Quantity Monitoring of Five Rainwater Tanks in Western Sydney, Australia. Journal of Environmental Engineering (New York, N.Y.), 139(3), 332–340. https://doi.org/10.1061/(ASCE)EE.1943-7870.0000614	This value is likely an overestimation and compares water quality of the first flush with the water quality stored in the tank.

First flush	*Enterococcus*	1.1	van der Sterren, M., Rahman, A., & Dennis, G. R. (2013). Quality and Quantity Monitoring of Five Rainwater Tanks in Western Sydney, Australia. Journal of Environmental Engineering (New York, N.Y.), 139(3), 332–340. https://doi.org/10.1061/(ASCE)EE.1943-7870.0000614	This value is likely an overestimation and compares water quality of the first flush with the water quality stored in the tank.
First flush	Fecal coliforms	0.4	Mendez, C. B., Klenzendorf, J. B., Afshar, B. R., Simmons, M. T., Barrett, M. E., Kinney, K. A., & Kirisits, M. J. (2011). The effect of roofing material on the quality of harvested rainwater. Water Research (Oxford), 45(5), 2049–2059. https://doi.org/10.1016/j.watres.2010.12.015	This value is estimated based on the data in figure 4. It represents the difference in concentration between the first flush and the stored water.
First flush	HPC	0.7	Lee, J. Y., Kim, H. J., & Han, M. Y. (2011). Quality assessment of rooftop runoff and harvested rainwater from a building catchment. Water Science and Technology, 63(11), 2725-2731.	This is likely an overestimate - this compares the concentration at 5 minutes after the start of the rain (identified as the highest turbidity) with stored water quality -- the stored water quality was typically worse than the water quality after 100 min of runoff (collected directly from the roof). Data was estimated from figure 3.
First flush	Thermotolerant coliforms	1.5	van der Sterren, M., Rahman, A., & Dennis, G. R. (2013). Quality and Quantity Monitoring of Five Rainwater Tanks in Western Sydney, Australia. Journal of Environmental Engineering (New York, N.Y.), 139(3), 332–340. https://doi.org/10.1061/(ASCE)EE.1943-7870.0000614	This value is likely an overestimation and compares water quality of the first flush with the water quality stored in the tank.

First flush	Total coliforms	0.0	Gikas, G. D., & Tsihrintzis, V. A. (2012). Assessment of water quality of first-flush roof runoff and harvested rainwater. Journal of Hydrology, 466, 115-126.	Six total systems represented in the study -- only four had paired median values of water in the first flush and water in the tank.
First flush	Total coliforms	-0.2	Gikas, G. D., & Tsihrintzis, V. A. (2017). Effect of first-flush device, roofing material, and antecedent dry days on water quality of harvested rainwater. Environmental Science and Pollution Research, 24, 21997-22006.	Compared water quality in the first flush diverter to water quality in two tanks, actually found more microbial contamination in the tanks
First flush	Total coliforms	0.7	Lee, J. Y., Kim, H. J., & Han, M. Y. (2011). Quality assessment of rooftop runoff and harvested rainwater from a building catchment. Water Science and Technology, 63(11), 2725-2731.	This is likely an overestimate - this compares the concentration at 5 minutes after the start of the rain (identified as the highest turbidity) with stored water quality -- the stored water quality was typically worse than the water quality after 100 min of runoff (collected directly from the roof). Data was estimated from figure 3.
First flush	Total coliforms	0.4	Mendez, C. B., Klenzendorf, J. B., Afshar, B. R., Simmons, M. T., Barrett, M. E., Kinney, K. A., & Kirisits, M. J. (2011). The effect of roofing material on the quality of harvested rainwater. Water Research (Oxford), 45(5), 2049–2059. https://doi.org/10.1016/j.watres.2010.12.015	This value is estimated based on the data in figure 4. It represents the difference in concentration between the first flush and the stored water.
First flush	Total coliforms	0.2	Sambas, N. F. B., Baloo, L., & Mustaffa, A. P. Z. (2019). Rainwater harvesting with subsequent first flush: Water quality performance for non-potable purpose. International Journal of Recent Technology and Engineering, 8(2 Spec), 76-79.	This is the comparison of the first first flush tank of 5 liters to the last first flush tank of 5 liters (there were 5 in total).

First flush	Total coliforms	1.9	van der Sterren, M., Rahman, A., & Dennis, G. R. (2013). Quality and Quantity Monitoring of Five Rainwater Tanks in Western Sydney, Australia. Journal of Environmental Engineering (New York, N.Y.), 139(3), 332–340. https://doi.org/10.1061/(ASCE)EE.1943-7870.0000614	This value is likely an overestimation and compares water quality of the first flush with the water quality stored in the tank.
Floating filter	*E. coli*	0.2	Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329.	These values are calculated from concentrations estimated from Fig. 3a and are values for system 1. The value is calculated as log(10)(average surface and midway concentration/average point of supply concentration) -- these numbers more accurately represent the difference between the surface and a lower point than the elevation of a traditional floating filter. The point of supply was 0.5m above the bottom of the tank, which was 2 m tall.
Floating filter	*E. coli*	0.4	Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329.	These values are calculated from concentrations estimated from Fig. 5a and are values for system 2. The value is calculated as log(10)(average all points except the point of supply/average point of supply concentration) -- The point of supply was 1.35 m above the bottom of the tank, which was 4.7 m tall.

In-tank settling (see note)	*E. coli*	2.8	Tran, S. H., Dang, H. T. T., Dao, D. A., Nguyen, V.-A., Nguyen, L. T., & Han, M. (2021). On-site rainwater harvesting and treatment for drinking water supply: assessment of cost and technical issues. Environmental Science and Pollution Research International, 28(10), 11928–11941. https://doi.org/10.1007/s11356-020-07977-0	This represents the numerical mean of the log reductions calculated for the single system for which data is reported in 2018 and 2019. The water was sampled in the sedimentation tank and then just before filtration. The first flush was diverted before the sedimentation tank. Zero values (all values after filtration) were replaced with 1 CFU/100 ml as a conservative estimate.
Floating filter	Fecal coliforms	0.3	Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329.	These values are calculated from concentrations estimated from Fig. 3a and are values for system 1. The value is calculated as log(10)(average surface and midway concentration/average point of supply concentration) -- these numbers more accurately represent the difference between the surface and a lower point than the elevation of a traditional floating filter. The point of supply was 0.5m above the bottom of the tank, which was 2 m tall.
Floating filter	Fecal coliforms	0.1	Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329.	These values are calculated from concentrations estimated from Fig. 5a and are values for system 2. The value is calculated as log(10)(average all points except the point of supply/average point of supply concentration) -- The point of supply was 1.35 m above the bottom of the tank, which was 4.7 m tall.

Floating filter	HPC	0.7	Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329.	These values are calculated from concentrations estimated from Fig. 3a and are values for system 1. The value is calculated as log(10)(average surface and midway concentration/average point of supply concentration) -- these numbers more accurately represent the difference between the surface and a lower point than the elevation of a traditional floating filter. The point of supply was 0.5m above the bottom of the tank, which was 2 m tall.
Floating filter	HPC	0.6	Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329.	These values are calculated from concentrations estimated from Fig. 5a and are values for system 2. The value is calculated as log(10)(average all points except the point of supply/average point of supply concentration) -- The point of supply was 1.35 m above the bottom of the tank, which was 4.7 m tall.
Biofilm and settling	HPC	0.2	van der Merwe, V., Duvenage, S., & Korsten, L. (2013). Comparison of biofilm formation and water quality when water from different sources was stored in large commercial water storage tanks. Journal of water and health, 11(1), 30–40. https://doi.org/10.2166/wh.2012.014	Reduction over 5 days

In-tank settling (see note)	HPC	1.0	Andriamanantena R., V., Kim, M., & Han, M. (2021). Effect of Visible Light on Surface-Attached and Suspended Heterotrophic Bacteria in a Typical Household Rainwater Harvesting Tank. Sustainability, 13(10), 5410-. https://doi.org/10.3390/su13105410	The heterotrophic plate count in the tank initially increased to approximately 3.5 (Fig. 5b), likely due to mixing of bacteria and available carbon sources when water was transferred from the rainwater harvesting system into this experimental tank. This value is based on the difference between the peak suspended heterotrophic plate count and the value one week later. These samples are from the tank stored without sunlight exposure to mimic appropriate design as required by Standard 63.
Biofilm and settling	*Pseudomonas*	2.0	Kim, M., & Han, M. (2015). Role of biofilms in improving microbial quality in rainwater tanks. Desalination and Water Treatment, 53(10), 2579-2584.	Based on 4-5 day reduction in concentration of two rainwater harvesting systems
In-tank settling (see note)	*Pseudomonas*	0.5	Tran, S. H., Dang, H. T. T., Dao, D. A., Nguyen, V.-A., Nguyen, L. T., & Han, M. (2021). On-site rainwater harvesting and treatment for drinking water supply: assessment of cost and technical issues. Environmental Science and Pollution Research International, 28(10), 11928–11941. https://doi.org/10.1007/s11356-020-07977-0	This represents the numerical mean of the log reductions calculated for the two systems for which data is reported in 2018 and 2019. The water was sampled in the sedimentation tank and then just before filtration. The first flush was diverted before the sedimentation tank. Zero values after filtration) were replaced with 1 CFU/100 ml as a conservative estimate. Data was not included for which the initial value was zero.

In-tank settling and biofilms (see note)	Viable bacteria at 30 degrees C	0.5	Kim, M., & Han, M. (2014). Characteristics of biofilm development in an operating rainwater storage tank. Environmental earth sciences, 72, 1633-1642.	This is between the inlet and outlet of a storage tank with baffles/walls set up to encourage settling. Biofilm growth was also monitored but impact on water quality was not directly measured --- improvement in water quality was attributed to the biofilm.
Floating filter	Total coliforms	0.3	Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329.	These values are calculated from concentrations estimated from Fig. 3a and are values for system 1. The value is calculated as log(10)(average surface and midway concentration/average point of supply concentration) -- these numbers more accurately represent the difference between the surface and a lower point than the elevation of a traditional floating filter. The point of supply was 0.5m above the bottom of the tank, which was 2 m tall.
Floating filter	Total coliforms	0.2	Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329.	These values are calculated from concentrations estimated from Fig. 5a and are values for system 2. The value is calculated as log(10)(average all points except the point of supply/average point of supply concentration) -- The point of supply was 1.35 m above the bottom of the tank, which was 4.7 m tall.
In-tank settling (see note)	Total coliforms	0.4	Tran, S. H., Dang, H. T. T., Dao, D. A., Nguyen, V.-A., Nguyen, L. T., & Han, M. (2021). On-site rainwater harvesting and treatment for drinking water supply: assessment of cost and technical issues. Environmental Science and Pollution	This represents the numerical mean of the log reductions calculated for the three sampled systems in 2018 and 2019. The water was sampled in the sedimentation tank and then just before filtration. The

			Research International, 28(10), 11928–11941. https://doi.org/10.1007/s11356-020-07977-0	first flush was diverted before the sedimentation tank.
Full system - including aeration tank, filtration (adsorption and sediment filtration), UV disinfection, first flush diversion and floating filter	Total coliforms	3.5	Khalid, B., & Alodah, A. (2023). Multivariate Analysis of Harvested Rainwater Quality Utilizing Sustainable Solar-Energy-Driven Water Treatment. Sustainability, 15(19), 14568-. https://doi.org/10.3390/su151914568	This value is calculated from the mean concentration of unfiltered rainwater and rainwater treated by the system - it is unclear how the untreated samples were collected
Full system - including aeration tank, filtration (adsorption and sediment filtration), UV disinfection, first flush diversion and floating filter	*E. coli*	3.0	Khalid, B., & Alodah, A. (2023). Multivariate Analysis of Harvested Rainwater Quality Utilizing Sustainable Solar-Energy-Driven Water Treatment. Sustainability, 15(19), 14568-. https://doi.org/10.3390/su151914568	This value is calculated from the mean concentration of unfiltered rainwater and rainwater treated by the system - it is unclear how the untreated samples were collected
Full system - no post-tank treatment	*E. coli*	0.5	Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329.	These values are calculated from percent reductions given in the text in the first paragraph on page 2323. NOTE: The text specifies that the reductions were "almost" this value.
Full system - no post-tank treatment	Fecal coliforms	0.8	Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329.	These values are calculated from percent reductions given in the text in the first paragraph on page 2323. NOTE: The text specifies that the reductions were "almost" this value.
Full system - no post-tank treatment	Total coliforms	1.0	Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in	These values are calculated from percent reductions given in the text in the first paragraph on page 2323. NOTE: The text

			Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329.	specifies that the reductions were "almost" this value.
Full system - no post-tank treatment	HPC	1.2	Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329.	These values are calculated from percent reductions given in the text in the first paragraph on page 2323. NOTE: The text specifies that the reductions were "almost" this value.
Full system, including chlorination and post-tank filtration	Fecal coliforms	0.7	Barriga, F., Gómez, G., Diez, M. C., Fernandez, L., & Vidal, G. (2024). Influence of Catchment Surface Material on Quality of Harvested Rainwater. Sustainability, 16(15), 6586-. https://doi.org/10.3390/su16156586	This is only for one site because it was the only site with an initial number for the coliform data in the untreated rainwater (2.7, all others were <1 MPN/100 ml). The value after treatment was <1, which was taken to be 0.5. The whole system is described as "The rainwater was captured by the different roof surfaces and conveyed through gutters to a stainless-steel mesh filter to retain leaves and larger solids. Then, the first millimeters of rain were conveyed to the first flush diverter to prevent particles, sediment, coloring, organic matter, and even pathogens that had accumulated on the roof, as well as pesticides and organic compounds entrained by the rain from the air, from reaching the water storage tank [14,16]. Once the rainwater reached the storage tank, it was disinfected by dosing with calcium hypochlorite (65% strength) in accordance with local regulations and the

				intended use of the harvested water. Finally, the water was extracted with a 0.5-HP pump to then pass through two filters with different pore sizes (130 µm and 5 µm) and harvested at the outlet tap for its end use."
Full system, including chlorination and post-tank filtration	Total coliforms		Barriga, F., Gómez, G., Diez, M. C., Fernandez, L., & Vidal, G. (2024). Influence of Catchment Surface Material on Quality of Harvested Rainwater. Sustainability, 16(15), 6586-. https://doi.org/10.3390/su16156586	Unable to calculate, because of low initial values (<1 MPN/100 ml)
Full system, including chlorination and post-tank filtration	*E. coli*		Barriga, F., Gómez, G., Diez, M. C., Fernandez, L., & Vidal, G. (2024). Influence of Catchment Surface Material on Quality of Harvested Rainwater. Sustainability, 16(15), 6586-. https://doi.org/10.3390/su16156586	Unable to calculate, because of low initial values (<1 MPN/100 ml)
Overflow	*E. coli*	1.7	van der Sterren, M., Rahman, A., & Dennis, G. R. (2013). Quality and Quantity Monitoring of Five Rainwater Tanks in Western Sydney, Australia. Journal of Environmental Engineering (New	This value compares concentrations measured in an overflow collection device to the water quality measured in the tank. The paper included limited detail on the

			York, N.Y.), 139(3), 332–340. https://doi.org/10.1061/(ASCE)EE.1943-7870.0000614	configuration of the overflow.
Overflow	Total coliforms	1.0	van der Sterren, M., Rahman, A., & Dennis, G. R. (2013). Quality and Quantity Monitoring of Five Rainwater Tanks in Western Sydney, Australia. Journal of Environmental Engineering (New York, N.Y.), 139(3), 332–340. https://doi.org/10.1061/(ASCE)EE.1943-7870.0000614	This value compares concentrations measured in an overflow collection device to the water quality measured in the tank. The paper included limited detail on the configuration of the overflow.
Overflow	*Enterococcus*	2.0	van der Sterren, M., Rahman, A., & Dennis, G. R. (2013). Quality and Quantity Monitoring of Five Rainwater Tanks in Western Sydney, Australia. Journal of Environmental Engineering (New York, N.Y.), 139(3), 332–340. https://doi.org/10.1061/(ASCE)EE.1943-7870.0000614	This value compares concentrations measured in an overflow collection device to the water quality measured in the tank. The paper included limited detail on the configuration of the overflow.
Overflow	Thermotolerant coliforms	1.0	van der Sterren, M., Rahman, A., & Dennis, G. R. (2013). Quality and Quantity Monitoring of Five Rainwater Tanks in Western Sydney, Australia. Journal of Environmental Engineering (New York, N.Y.), 139(3), 332–340. https://doi.org/10.1061/(ASCE)EE.1943-7870.0000614	This value compares concentrations measured in an overflow collection device to the water quality measured in the tank. The paper included limited detail on the configuration of the overflow.
Pre-tank filter	Thermotolerant coliforms		Costa, P. C. L. da, Azevedo, A. R. G. de, Silva, F. C. da, Cecchin, D., & Carmo, D. de F. do. (2021). Rainwater treatment using an acrylic blanket as a filtering media. Journal of Cleaner Production, 303, 126964-.	Unable to calculate a value because the target organism was absent in both pre and post-filtration samples

			https://doi.org/10.1016/j.jclepro.2021.126964	
Pre-tank filter	Total coliforms		Costa, P. C. L. da, Azevedo, A. R. G. de, Silva, F. C. da, Cecchin, D., & Carmo, D. de F. do. (2021). Rainwater treatment using an acrylic blanket as a filtering media. Journal of Cleaner Production, 303, 126964-. https://doi.org/10.1016/j.jclepro.2021.126964	Unable to calculate a value because the target organism was absent in both pre and post-filtration samples
Pre-tank filter	Total coliforms	0.5	Taffere, G. R., Beyene, A., Vuai, S. A. H., Gasana, J., & Seleshi, Y. (2017). Dilemma of roof rainwater quality: applications of physical and organic treatment methods in a water scarce region of Mekelle, Ethiopia. Urban Water Journal, 14(5), 460–466. https://doi.org/10.1080/1573062X.2016.1176225	Pre Tank filtration is with a slow-sand filter.
Pre-tank filter and first flush	E. coli	0.1	Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329.	These values are calculated from concentrations estimated from Fig. 3b and are values for system 1. The log reduction value compares sampling point S1,1 with S1,2.
Pre-tank filter and first flush	Fecal coliforms	0.1	Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329.	These values are calculated from concentrations estimated from Fig. 3b and are values for system 1. The log reduction value compares sampling point S1,1 with S1,2.

Pre-tank filter and first flush	Total coliforms	0.1	Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329.	These values are calculated from concentrations estimated from Fig. 3b and are values for system 1. The log reduction value compares sampling point S1,1 with S1,2.
Pre-tank filter and first flush	HPC	0.2	Amin, M. T., Kim, T. I., Amin, M. N., & Han, M. Y. (2013). Effects of Catchment, First-Flush, Storage Conditions, and Time on Microbial Quality in Rainwater Harvesting Systems. Water Environment Research, 85(12), 2317-2329.	These values are calculated from concentrations estimated from Fig. 3b and are values for system 1. The log reduction value compares sampling point S1,1 with S1,2.

APPENDIX B: Additional papers assessed for information but not included in the table

Reference	**Exclusion reason**
Ahammed, M. M., & Meera, V. (2010). Metal oxide/hydroxide-coated dual-media filter for simultaneous removal of bacteria and heavy metals from natural waters. Journal of Hazardous Materials, 181(1), 788–793. https://doi.org/10.1016/j.jhazmat.2010.05.082	Post-tank treatment only
Abedin, Md. A., Collins, A. E., Habiba, U., & Shaw, R. (2019). Climate Change, Water Scarcity, and Health Adaptation in Southwestern Coastal Bangladesh. International Journal of Disaster Risk Science, 10(1), 28–42. https://doi.org/10.1007/s13753-018-0211-8	No water quality data
Acharya, S., Datta, R., & Debnath, B. (2023). Theoretical and experimental investigations of an integrated rainwater harvesting system for electricity and drinking water. Environmental Science and Pollution Research International, 30(24), 66359–66371. https://doi.org/10.1007/s11356-023-27120-z	No water quality data
Acharya, S., Datta, R., & Debnath, B. (2023). Theoretical and experimental investigations of an integrated rainwater harvesting system for electricity and drinking water. Environmental Science and Pollution Research International, 30(24), 66359–66371.	No water quality data

https://doi.org/10.1007/s11356-023-27120-z	
Ahmed, W., Huygens, F., Goonetilleke, A., & Gardner, T. (2008). Real-time PCR detection of pathogenic microorganisms in roof-harvested rainwater in Southeast Queensland, Australia. Applied and environmental microbiology, 74(17), 5490–5496. https://doi.org/10.1128/AEM.00331-08	Sampling of existing systems only --- no information on system design
Ahmed, W., Vieritz, A., Goonetilleke, A., & Gardner, T. (2010). Health risk from the use of roof-harvested rainwater in Southeast Queensland, Australia, as potable or nonpotable water, determined using quantitative microbial risk assessment. Applied and environmental microbiology, 76(22), 7382–7391. https://doi.org/10.1128/AEM.00944-10	Sampling of existing systems only --- no information on system design
Alam, K., & Rahman, Md. H. (2019). Post-disaster recovery in the cyclone Aila affected coastline of Bangladesh: women's role, challenges and opportunities. Natural Hazards (Dordrecht), 96(3), 1067–1090. https://doi.org/10.1007/s11069-019-03591-7	No water quality data
Alderton, S. (2020). Tips to harvest rainwater on farm. Farmers Weekly, 173(13), 38–39.	Not peer reviewed
Alegbeleye, O., & Sant'Ana, A. S. (2023). Microbiological quality of irrigation water collected from vegetable farms in Sao Paulo, Brazil during the dry and rainy season. Agricultural Water Management, 279, 108190-. https://doi.org/10.1016/j.agwat.2023.108190	Samples only at one point in the water systems, cannot assess treatment
Alim, M. A., Rahman, A., Tao, Z., Samali, B., Khan, M. M., & Shirin, S. (2020). Feasibility analysis of a small-scale rainwater harvesting system for drinking water production at Werrington, New South Wales, Australia. Journal of Cleaner Production, 270, 122437-. https://doi.org/10.1016/j.jclepro.2020.122437	Simulation study only
Ambast, S. K., Tyagi, N. K., & Raul, S. K. (2006). Management of declining groundwater in the Trans Indo-Gangetic Plain (India): Some options. Agricultural Water Management, 82(3), 279–296. https://doi.org/10.1016/j.agwat.2005.06.005	No rainwater quality data
Amin, M. T., & Han, M. Y. (2009). Roof-harvested rainwater for potable purposes: Application of solar collector disinfection (SOCO-DIS). Water Research (Oxford), 43(20), 5225–5235. https://doi.org/10.1016/j.watres.2009.08.041	Studied solar disinfection - post-tank treatment

Anstiss, R. G., & Ahmed, M. (2007). A Conceptual Model to be Used for Community-based Drinking-water Improvements. Journal of Health, Population and Nutrition, 24(3).	No water quality data - conceptual paper only
Antão- Geraldes, A. M., Pinto, M. F. G. D. A., Afonso, M. J., Albuquerque, A., Calheiros, C., & Silva, F. (2023). Promoting water efficiency in a municipal market building: a case study. Hydrology, 10(3), 69-. https://doi.org/10.3390/hydrology10030069	Modeling study only - no water quality data
Aru Yudhantoro, W., Warno Utomo, S., & Nowo Martono, D. (2020). Water Reuse Planning for Fulfilment of Clean Water in Indonesia. E3S Web of Conferences, 202, 3002-. https://doi.org/10.1051/e3sconf/202020203002	Conference paper - no water quality data
Ashrafuzzaman, M. (2023). Local Context of Climate Change Adaptation in the South-Western Coastal Region of Bangladesh. Sustainability, 15(8), 6664-. https://doi.org/10.3390/su15086664	No water quality data
Ashrafuzzaman, M., Gomes, C., & Guerra, J. (2023). The Changing Climate Is Changing Safe Drinking Water, Impacting Health: A Case in the Southwestern Coastal Region of Bangladesh (SWCRB). Climate (Basel), 11(7), 146-. https://doi.org/10.3390/cli11070146	No water quality data
Bae, S., Maestre, J. P., Kinney, K. A., & Kirisits, M. J. (2019). An examination of the microbial community and occurrence of potential human pathogens in rainwater harvested from different roofing materials. Water research, 159, 406–413. https://doi.org/10.1016/j.watres.2019.05.029	No treatment included -- only roof runoff studied. The paper did exclude the first flush, but this was not compared with later harvested rainwater anywhere in the paper.
Bani, S., Matambo, C., Limson, J., Zuma, B. M., & Tandlich, R. (2024). Operation and Performance of The Lab and Pilotscale Greywater Treatment Systems: Biochar and Gravel Use in South Africa. The Journal of Solid Waste Technology and Management, 50(1), 458–478. https://doi.org/10.5276/jswtm/iswmaw/501/2024.458	Greywater treatment - not rainwater
BUSINESS BRIEFS. (2015). Poultry World, 170(7), 18-.	Not a research paper, no rainwater harvesting data
Castier, M., & de Barros Barreto, P. (2023). Economic attractiveness of domestic rainwater harvesting in Brazilian cities. Discover Water, 3(1), 9–9. https://doi.org/10.1007/s43832-023-00033-1	No water quality data

Chai, H., Chen, Z., Shao, Z., Deng, S., Li, L., Xiang, Y., Li, L., Hu, X., & He, Q. (2019). Long-term pollutant removal performance and mitigation of rainwater quality deterioration with ceramsite and Cyperus alternifolius in mountainous cities of China. Environmental Science and Pollution Research International, 26(32), 32993–33003. https://doi.org/10.1007/s11356-019-06328-y	No microbial water quality data
Chamberlain, J. F., & Sabatini, D. A. (2014). Water-supply options in arsenic-affected regions in Cambodia: Targeting the bottom income quintiles. The Science of the Total Environment, 488–489, 521–531. https://doi.org/10.1016/j.scitotenv.2013.12.011	No water quality data
Chen Qiuli, Sun Hongwei, & Chen Shiguang. (2021). Performance of an innovative gravity-driven micro-filtration technology for roof rainwater treatment. Environmental Engineering Research, 26(6), 20–28.	Studied ceramic filter - post-tank treatment
Chen, C.-F., Chen, Y.-W., Lin, C.-H., & Lin, J.-Y. (2024). Field performance of 15 rain gardens in different cities in Taiwan. The Science of the Total Environment, 947, 174545-. https://doi.org/10.1016/j.scitotenv.2024.174545	Samples only at one point in the water systems, cannot assess treatment
Chidamba, L., & Korsten, L. (2015). Pyrosequencing analysis of roof-harvested rainwater and river water used for domestic purposes in Luthengele village in the Eastern Cape Province of South Africa. Environmental Monitoring and Assessment, 187(2), 41–17. https://doi.org/10.1007/s10661-014-4237-0	Single samples only from systems
Chidamba, L., & Korsten, L. (2018). Relative proportions of E. coli and Enterococcus spp. may be a good indicator of potential health risks associated with the use of roof harvested rainwater stored in tanks. Environmental monitoring and assessment, 190(3), 177. https://doi.org/10.1007/s10661-018-6554-1	Sampling of existing systems only --- no information on system design
Chubaka, C. E., Whiley, H., Edwards, J. W., & Ross, K. E. (2018). Lead, Zinc, Copper, and Cadmium Content of Water from South Australian Rainwater Tanks. International Journal of Environmental Research and Public Health, 15(7), 1551-. https://doi.org/10.3390/ijerph15071551	Small amount of samples looked at pre and post filter, but not enough data given to calculate percent reductions

Chubaka, C. E., Whiley, H., Edwards, J. W., & Ross, K. E. (2018). Microbiological Values of Rainwater Harvested in Adelaide. Pathogens (Basel), 7(1), 21-. https://doi.org/10.3390/pathogens7010021	Contained data from samples before and after post-tank filtration systems on multiple homes, but no information was given on the filtration, unclear if it was just filters or if it included UV or similar
Clark, G. G., Jamal, R., & Weidhaas, J. (2019). Roofing material and irrigation frequency influence microbial risk from consuming homegrown lettuce irrigated with harvested rainwater. The Science of the total environment, 651(Pt 1), 1011–1019. https://doi.org/10.1016/j.scitotenv.2018.09.277	Direct sampling of roof runoff only
D' Silva, T. C., Verma, S., Magdaline, R. M., Chandra, R., & Khan, A. A. (2022). Environmental resilience and sustainability through green technologies: A case evidence from rural coastal India. Environmental Engineering Research, 27(5), 210262-. https://doi.org/10.4491/eer.2021.262	Computational only, no water quality data
de Kwaadsteniet, M., Dobrowsky, P. H., van Deventer, A., Khan, W., & Cloete, T. E. (2013). Domestic Rainwater Harvesting: Microbial and Chemical Water Quality and Point-of-Use Treatment Systems. Water, Air, and Soil Pollution, 224(7), 1–19. https://doi.org/10.1007/s11270-013-1629-7	Review paper only
Delaney, R. G., Blackburn, G. A., Whyatt, J. D., & Folkard, A. M. (2022). SiteFinder: A geospatial scoping tool to assist the siting of external water harvesting structures. Agricultural Water Management, 272, 107836-. https://doi.org/10.1016/j.agwat.2022.107836	No water quality data - modeling study
Demuzere, M., Coutts, A. M., Göhler, M., Broadbent, A. M., Wouters, H., van Lipzig, N. P. M., & Gebert, L. (2014). The implementation of biofiltration systems, rainwater tanks and urban irrigation in a single-layer urban canopy model. Urban Climate, 10, 148–170. https://doi.org/10.1016/j.uclim.2014.10.012	No water quality data
Diehl de Souza, T., & Ghisi, E. (2020). Harvesting rainwater from scaffolding platforms and walls to reduce potable water consumption at buildings construction sites. Journal of Cleaner Production, 258, 120909-. https://doi.org/10.1016/j.jclepro.2020.120909	Modeling study only - no water quality data

Dissanayake, J., & Han, M. (2021). The effect of number of tanks on water quality in rainwater harvesting systems under sudden contaminant input. The Science of the Total Environment, 769, 144553-. https://doi.org/10.1016/j.scitotenv.2020.144553	experimental study using kaolin clay or salt as a tracer - no microbial data
Dobrowsky, P. H., Khan, S., Cloete, T. E., & Khan, W. (2016). Molecular detection of Acanthamoeba spp., Naegleria fowleri and Vermamoeba (Hartmannella) vermiformis as vectors for Legionella spp. in untreated and solar pasteurized harvested rainwater. Parasites & Vectors, 9(1), 539–539. https://doi.org/10.1186/s13071-016-1829-2	Studied solar pasteurization, post tank treatment only
Dobrowsky, P. H., Lombard, M., Cloete, W. J., Saayman, M., Cloete, T. E., Carstens, M., Khan, S., & Khan, W. (2015). Efficiency of Microfiltration Systems for the Removal of Bacterial and Viral Contaminants from Surface and Rainwater. Water, Air, and Soil Pollution, 226(3), 1–14. https://doi.org/10.1007/s11270-015-2317-6	Post-tank treatment only
Doyle, K., & Shanahan, P. (2010, November). The impact of first flush removal on rainwater quality and rainwater harvesting systems' reliability in rural Rwanda. In World Environmental and Water Resources Congress 2010: Challenges of Change (pp. 465-474).	Conference paper only
Du, X., Ma, R., Liang, Z., Kuang, K., Chu, L., Liu, L., Song, W., & Tian, J. (2023). Flux Improvement and Biofilm Performance of an Oblique Gravity-Driven Ceramic Membrane Bioreactor Coupled with Electrocoagulation for Roofing Rainwater Purification. ACS ES&T Engineering, 3(11), 1813–1825. https://doi.org/10.1021/acsestengg.3c00236	Studied post tank treatment only
Du, X., Ma, R., Xiao, M., Song, W., Tan, Y., Wang, Z., Ng, A. H.-M., & Zhang, W. (2022). Integrated electro-coagulation and gravity driven ceramic membrane bioreactor for roofing rainwater purification: Flux improvement and extreme operating case. The Science of the Total Environment, 851, 158197–158197. https://doi.org/10.1016/j.scitotenv.2022.158197	Studied post tank treatment only
Du, X., Wang, Z., Liu, Y., Ma, R., Lu, S., Lu, X., Liu, L., & Liang, H. (2022). Gravity-driven membrane bioreactor coupled with electrochemical oxidation disinfection (GDMBR-EO) to treat roofing rainwater. Chemical Engineering Journal (Lausanne, Switzerland : 1996), 427, 131714-. https://doi.org/10.1016/j.cej.2021.131714	Studied gravity-driven membrane bioreactor-post tank treatment only

Du, X., Xu, J., Mo, Z., Luo, Y., Su, J., Nie, J., Wang, Z., Liu, L., & Liang, H. (2019). The performance of gravity-driven membrane (GDM) filtration for roofing rainwater reuse: Implications of roofing rainwater energy and rainwater purification. The Science of the Total Environment, 697, 134187–134187. https://doi.org/10.1016/j.scitotenv.2019.134187	Membrane filtration -- post tank treatment only
Ekowati, S. D., & Hadi, S. P. (2020). Multi Effect of Rain Harvesting in the Floating Village of Malahing on the Coast Bontang Developed by the CSR of PKT. IOP Conference Series. Earth and Environmental Science, 448(1), 12129-. https://doi.org/10.1088/1755-1315/448/1/012129	Conference paper - no water quality data
Evans, C. A., Coombes, P. J., Dunstan, R. H., & Harrison, T. (2009). Extensive bacterial diversity indicates the potential operation of a dynamic micro-ecology within domestic rainwater storage systems. Science of the Total Environment, 407(19), 5206-5215.	Rainwater quality data from only one point in the system
Evans, C. A., Coombes, P. J., Dunstan, R. H., & Harrison, T. (2009). Extensive bacterial diversity indicates the potential operation of a dynamic micro-ecology within domestic rainwater storage systems. The Science of the total environment, 407(19), 5206–5215. https://doi.org/10.1016/j.scitotenv.2009.06.009	Tap samples only - no possibility to calculate reductions
Evans, C. A., Coombes, P. J., Dunstan, R. H., Harrison, T., Martin, A., & Harris, J. N. (2006). Coliforms, biofilms, microbial diversity and the quality of roof-harvested rainwater. Water Res, 40(1), 34-44.	Samples taken in two locations from tanks, but no clear treatment step from Standard 63 between them "For the determination of tank water bacterial counts, samples were collected both from within the tank, by submerging a sterile container 30 cm below the water surface, as well as from the tap outlet connected directly to the tank"
Farrell, A., Swan, D. A., & R. Mendes, D. R. L. (2021). Rainwater Harvesting in the Rainforest: A Technical and Socioeconomic Review of Community Approaches in Brazil. IOP Conference Series. Materials Science and Engineering, 1196(1), 12003-. https://doi.org/10.1088/1757-899X/1196/1/012003	Conference paper

Farreny, R., Morales-Pinzón, T., Guisasola, A., Tayà, C., Rieradevall, J., & Gabarrell, X. (2011). Roof selection for rainwater harvesting: Quantity and quality assessments in Spain. Water Research (Oxford), 45(10), 3245–3254. https://doi.org/10.1016/j.watres.2011.03.036	physicochemical quality only
Feng, W., Hatt, B. E., McCarthy, D. T., Fletcher, T. D., & Deletic, A. (2012). Biofilters for Stormwater Harvesting: Understanding the Treatment Performance of Key Metals That Pose a Risk for Water Use. Environmental Science & Technology, 46(9), 5100–5108. https://doi.org/10.1021/es203396f	No microbial water quality data
Fraga, B. D., Maldonado, M. U., & Miguel, P. A. C. (2018). Mapeamento da produção tecnológica sobre aproveitamento de água da chuva: uma análise bibliométrica a partir de patentes. Revista Produção Online, 18(4), 1279–1300. https://doi.org/10.14488/1676-1901.v18i4.2827	No water quality data
Galvis, A., Zambrano, D. A., van der Steen, N. P., & Gijzen, H. J. (2014). Evaluation of pollution prevention options in the municipal water cycle. Journal of Cleaner Production, 66, 599–609. https://doi.org/10.1016/j.jclepro.2013.10.057	Computational only - no sampling
Gao, Z., Zhang, Q., Li, J., Wang, Y., Dzakpasu, M., & Wang, X. C. (2023). First flush stormwater pollution in urban catchments: A review of its characterization and quantification towards optimization of control measures. Journal of Environmental Management, 340, 117976–117976. https://doi.org/10.1016/j.jenvman.2023.117976	Review paper
Gao, Z., Zhang, Q., Wang, Y., Dzakpasu, M., & Wang, X. C. (2024). Contaminant distribution and migration in roofing rainwater: Implications for sustainable utilization and pollution control. Journal of Water Process Engineering, 61, 105298-. https://doi.org/10.1016/j.jwpe.2024.105298	No microbial water quality data
Gee, K. D., Schimoler, D., Charron, B. T., Woodward, M. D., & Hunt, W. F. (2021). A Comparison of Methods to Address Anaerobic Conditions in Rainwater Harvesting Systems. Water (Basel), 13(23), 3419-. https://doi.org/10.3390/w13233419	No microbial water quality data
Ghura, A. S., & Abhishek. (2023). VARDHMAN ENVIROTECH: CREATING BLUE OCEAN AND REINVENTING BUSINESS MODEL. Asian Case Research Journal, 27(3), 253–263. https://doi.org/10.1142/S0218927523500165	No water quality data

Glick, R., Jeong, J., Srinivasan, R., Arnold, J. G., & Her, Y. (2023). Adaptation of SWAT Watershed Model for Stormwater Management in Urban Catchments: Case Study in Austin, Texas. Water (Basel), 15(9), 1770-. https://doi.org/10.3390/w15091770	No water quality data- simulation study
Grabowski, T., Bochniak, A., Siwiec, T., & Jóźwiakowski, K. (2024). Pollutant Removal Efficiency in a Rainwater Treatment System in Roztocze National Park (Poland). Sustainability, 16(11), 4709-. https://doi.org/10.3390/su16114709	Post-tank treatment only
Grabowski, T., Jóźwiakowski, K., Bochniak, A., Stachyra, P., & Radliński, B. (2023). Assessment of Rainwater Quality Regarding its Use in The Roztocze National Park (Poland)—Case Study. Applied Sciences, 13(10), 6110-. https://doi.org/10.3390/app13106110	Water quality data at only one point -- just roof runoff- no ability to assess treatment
Gregory, E. C., & Victor, N. U. (2018). Impact of Proliferation of Borehole Development Projects on Groundwater Quality in Abia State, Nigeria. International Journal of Biosciences and Technology, 11(2), 20–29.	No rainwater harvesting data
Hafizi Md Lani, N., Yusop, Z., & Syafiuddin, A. (2018). A Review of Rainwater Harvesting in Malaysia: Prospects and Challenges. Water (Basel), 10(4), 506-. https://doi.org/10.3390/w10040506	No rainwater quality data - review paper
Halim, Z., Din, A., Tokit, E., & Rosli, M. (2019). Development of Rainwater Harvesting System for Sekolah Menengah Kebangsaan Iskandar Syah Melaka. IOP Conference Series. Earth and Environmental Science, 268(1), 12024-. https://doi.org/10.1088/1755-1315/268/1/012024	Conference paper only
Hameed, A., Arooj, F., Luqman, M., Kashif, S. ur R., Iftikhar, A., Aziz ur Rehman, S., Najeeb, I., & Ahmed Somroo, Z. (2022). Assessment of Filtration System Efficiency of Artificial Groundwater Recharge wells in Lahore. Polish Journal of Environmental Studies, 31(3), 2625–2636. https://doi.org/10.15244/pjoes/143921	Examined specially designed filter system for groundwater recharge - not applicable to ARCSA standard
Hammes, G., Thives, L. P., & Ghisi, E. (2018). Application of stormwater collected from porous asphalt pavements for non-potable uses in buildings. Journal of Environmental Management, 222, 338–347. https://doi.org/10.1016/j.jenvman.2018.05.094	Filtration was porous pavers - not included in Standard 63

Harun, M. A. Y. A., & Kabir, G. M. M. (2013). Evaluating pond sand filter as sustainable drinking water supplier in the Southwest coastal region of Bangladesh. Applied Water Science, 3(1), 161–166. https://doi.org/10.1007/s13201-012-0069-7	No rainwater harvesting data
Hassan, M. M. (2005). Arsenic poisoning in Bangladesh: spatial mitigation planning with GIS and public participation. Health Policy (Amsterdam), 74(3), 247–260. https://doi.org/10.1016/j.healthpol.2005.01.008	No rainwater harvesting data
Heidy Gabriela, R. M., & Jose Vladimir, C. T. (2022). Rainwater harvesting system as a strategy for adaptation on climate change: A review. IOP Conference Series. Earth and Environmental Science, 1121(1), 12007-. https://doi.org/10.1088/1755-1315/1121/1/012007	Conference paper - review paper
Helmreich, B., & Horn, H. (2009). Opportunities in rainwater harvesting. Desalination, 248(1), 118–124. https://doi.org/10.1016/j.desal.2008.05.046	Review paper only
Hoque, B. A., Hoque, M. M., Ahmed, T., Islam, S., Azad, A. K., Ali, N., Hossain, M., & Hossain, M. S. (2004). Demand-based water options for arsenic mitigation: an experience from rural Bangladesh. Public Health (London), 118(1), 70–77. https://doi.org/10.1016/S0033-3506(03)00135-5	review paper
Hossain, M., Rahman, S. N., Bhattacharya, P., Jacks, G., Saha, R., & Rahman, M. (2015). Sustainability of arsenic mitigation interventions—an evaluation of different alternative safe drinking water options provided in Matlab, an arsenic hot spot in Bangladesh. Frontiers in Environmental Science, 3(30). https://doi.org/10.3389/fenvs.2015.00030	No water quality data from rainwater harvesting
Howard, G., Ahmed, M. F., Shamsuddin, A. J., Mahmud, S. G., & Deere, D. (2007). Risk Assessment of Arsenic Mitigation Options in Bangladesh. Journal of Health, Population and Nutrition, 24(3).	No rainwater harvesting water quality data
Hussain, F., Hussain, R., Wu, R.-S., & Abbas, T. (2019). Rainwater Harvesting Potential and Utilization for Artificial Recharge of Groundwater Using Recharge Wells. Processes, 7(9), 623-. https://doi.org/10.3390/pr7090623	No water quality data from rainwater harvesting
Hussain, M. D., & Ziauddin, A. T. M. (1992). Rainwater harvesting and storage techniques from Bangladesh. Waterlines, 10(3), 10–12. https://doi.org/10.3362/0262-8104.1992.003	No water quality data from rainwater harvesting

Im, J., & Yoon, J. (2024). Promoting Green Infrastructure Awareness through Education: Pre- and Post-Assessments of Its Effectiveness. Landscape Journal, 43(1), 49–68. https://doi.org/10.3368/lj.43.1.49	No water quality data from rainwater harvesting
Inauen, J., Hossain, M. M., Johnston, R. B., & Mosler, H.-J. (2013). Acceptance and use of eight arsenic-safe drinking water options in Bangladesh. PloS One, 8(1), e53640-. https://doi.org/10.1371/journal.pone.0053640	No water quality data from rainwater harvesting
Islam, Md. A., Karim, Md. R., Higuchi, T., Sakakibara, H., & Sekine, M. (2014). Comparison of the trace metal concentration of drinking water supply options in southwest coastal areas of Bangladesh. Applied Water Science, 4(2), 183–191. https://doi.org/10.1007/s13201-013-0140-z	Samples only at one point in the system
Jaiyeola, A. T. (2017). The management and treatment of airport rainwater in a water-scarce environment. International Journal of Environmental Science and Technology (Tehran), 14(2), 421–434. https://doi.org/10.1007/s13762-016-1122-0	No water quality data
Jakariya, M., Rahman, M. M., Mahzabin, L., Chowdhury, A., Adiba, H., Alam, Md. S., Murshed, M. F., Sonne, C., Barceló, D., Chen, J., Islam, Md. A., & Bhattacharya, P. (2024). Changing water sources and extraction methods in Bangladesh: Challenges, consequences, and sustainable solutions. Groundwater for Sustainable Development, 25, 101129-. https://doi.org/10.1016/j.gsd.2024.101129	No water quality data
James, D. (2020). What's in Your Livestock Shed? Farmers Weekly, 173(11), 30–31.	Not peer-reviewed
Jiang, Y., Yuan, Y., & Piza, H. (2015). A Review of Applicability and Effectiveness of Low Impact Development/Green Infrastructure Practices in Arid/Semi-Arid United States. Environments (Basel, Switzerland), 2(4), 221–249. https://doi.org/10.3390/environments2020221	review paper
Jing, X., Zhang, S., Zhang, J., Wang, Y., & Wang, Y. (2017). Assessing efficiency and economic viability of rainwater harvesting systems for meeting non-potable water demands in four climatic zones of China. Resources, Conservation and Recycling, 126, 74–85. https://doi.org/10.1016/j.resconrec.2017.07.027	Computational only - no sampling

Jones, T. R., Poitras, J., Levett, A., Langendam, A., Vietti, A., & Southam, G. (2023). Accelerated carbonate biomineralisation of Venetia diamond mine coarse residue deposit (CRD) material – A field trial study. The Science of the Total Environment, 893, 164853–164853. https://doi.org/10.1016/j.scitotenv.2023.164853	Not about rainwater harvesting
Jordan, F. L., Seaman, R., Riley, J. J., & Yoklic, M. R. (2008). Effective removal of microbial contamination from harvested rainwater using a simple point of use filtration and UV-disinfection device. Urban Water Journal, 5(3), 209-218.	Single samples only from systems
Judeh, T., Shahrour, I., & Comair, F. (2022). Smart Rainwater Harvesting for Sustainable Potable Water Supply in Arid and Semi-Arid Areas. Sustainability, 14(15), 9271-. https://doi.org/10.3390/su14159271	Modeling study only - no water quality data
Julien, R., Dreelin, E., Whelton, A. J., Lee, J., Aw, T. G., Dean, K., & Mitchell, J. (2020). Knowledge gaps and risks associated with premise plumbing drinking water quality. AWWA Water Science, 2(3). https://doi.org/10.1002/aws2.1177	No water quality samples
Karima, A., & Shafiul Islam, Kh. M. (2020). Drinking water desalination using low-cost Tubular Solar Still. Applied Water Science, 10(1), 1–6. https://doi.org/10.1007/s13201-019-1093-7	No water quality data from rainwater harvesting
Kasmin, H., Bakar, N. H., & Zubir, M. M. (2016). Monitoring on The Quality and Quantity of DIY Rainwater Harvesting System. IOP Conference Series. Materials Science and Engineering, 136(1), 12067–12074. https://doi.org/10.1088/1757-899X/136/1/012067	Conference paper
Keithley, S. E., Fakhreddine, S., Kinney, K. A., & Kirisits, M. J. (2018). Effect of Treatment on the Quality of Harvested Rainwater for Residential Systems. Journal - American Water Works Association, 110(7), E1–E11. https://doi.org/10.1002/awwa.1054	Post-tank treatment only
Khan, Md. S., & Paul, S. K. (2023). Fresh water management in coastal Bangladesh: preparedness and adaptation. Discover Water, 3(1), 27–14. https://doi.org/10.1007/s43832-023-00052-y	Surveys only, no rainwater harvesting data
Kim, J. E., Humphrey, D., & Hofman, J. (2022). Evaluation of harvesting urban water resources for sustainable water management: Case study in Filton Airfield, UK. Journal of Environmental Management, 322, 116049–116049. https://doi.org/10.1016/j.jenvman.2022.116049	Samples only at one point in the system

Kim, T., Lye, D., Donohue, M., Mistry, J. H., Pfaller, S., Vesper S., & Kiristis, M. J. (2016). Harvested Rainwater Quality Before and After Treatment and Distribution in Residential Systems. Journal - American Water Works Association, 108(11), E571–E584. https://doi.org/10.5942/jawwa.2016.108.0182	Post-tank treatment only
Köster, S., Hadler, G., Opitz, L., & Thoms, A. (2023). Using Stormwater in a Sponge City as a New Wing of Urban Water Supply—A Case Study. Water (Basel), 15(10), 1893-. https://doi.org/10.3390/w15101893	Post-tank treatment only
Kucukkaya, E., Kelesoglu, A., Gunaydin, H., Kilic, G. A., & Unver, U. (2021). Design of a passive rainwater harvesting system with green building approach. International Journal of Sustainable Energy, 40(2), 175–187. https://doi.org/10.1080/14786451.2020.1801681	No water quality data
Kuller, M., Dolman, N. J., Vreeburg, J. H. G., & Spiller, M. (2017). Scenario analysis of rainwater harvesting and use on a large scale - assessment of runoff, storage and economic performance for the case study Amsterdam Airport Schiphol. Urban Water Journal, 14(3), 237–246. https://doi.org/10.1080/1573062X.2015.1086007	No water quality data
Kus, B., Kandasamy, J., Vigneswaran, S., & Shon, H. K. (2010). Analysis of first flush to improve the water quality in rainwater tanks. Water science and technology : a journal of the International Association on Water Pollution Research, 61(2), 421–428. https://doi.org/10.2166/wst.2010.823	Recorded water quality data in runoff through time -- no sampling of multiple points in a rainwater system
Lakshminarayana, S. V., Sathian, K. K., & Prakash, K. A. (2017). Performance Evaluation of First Flush with Micromesh Filter System under Actual Rainfall Condition. Int. J. Curr. Microbiol. App. Sci, 6(3), 292-300.	No microbial data, small prototype of a system using mesh (60 micron and smaller) for filtration
Lay, J. J., Vogel, J. R., Belden, J. B., Brown, G. O., & Storm, D. E. (2024). Water Quality and the First-Flush Effect in Roof-Based Rainwater Harvesting, Part I: Water Quality and Soil Accumulation. Water (Basel), 16(10), 1402-. https://doi.org/10.3390/w16101402	Single sample location only from systems
Lay, J. J., Vogel, J. R., Belden, J. B., Brown, G. O., & Storm, D. E. (2024). Water Quality and the First-Flush Effect in Roof-Based Rainwater Harvesting, Part II: First Flush. Water (Basel), 16(10), 1421-. https://doi.org/10.3390/w16101421	No microbial data presented

Leong, J. Y. C., Chong, M. N., & Poh, P. E. (2018). Assessment of greywater quality and performance of a pilot-scale decentralised hybrid rainwater-greywater system. Journal of Cleaner Production, 172, 81–91. https://doi.org/10.1016/j.jclepro.2017.10.172	Greywater samples only
Leong, J. Y. C., Oh, K. S., Poh, P. E., & Chong, M. N. (2017). Prospects of hybrid rainwater-greywater decentralised system for water recycling and reuse: A review. Journal of Cleaner Production, 142, 3014–3027. https://doi.org/10.1016/j.jclepro.2016.10.167	Review paper
Lepcha, R., Kumar Patra, S., Ray, R., Thapa, S., Baral, D., & Saha, S. (2024). Rooftop rainwater harvesting a solution to water scarcity: A review. Groundwater for Sustainable Development, 26, 101305-. https://doi.org/10.1016/j.gsd.2024.101305	Review paper only
Ley, C. J., Proctor, C. R., Jordan, K., Ra, K., Noh, Y., Odimayomi, T., Julien, R., Kropp, I., Mitchell, J., Nejadhashemi, A. P., Whelton, A. J., & Aw, T. G. (2020). Impacts of Municipal Water–Rainwater Source Transitions on Microbial and Chemical Water Quality Dynamics at the Tap. Environmental Science & Technology, 54(18), 11453–11463. https://doi.org/10.1021/acs.est.0c03641	All samples taken after the tank - no data available for comparison
Liu, L., Fu, Y., Wei, Q., Liu, Q., Wu, L., Wu, J., & Huo, W. (2019). Applying Bio-Slow Sand Filtration for Water Treatment. Polish Journal of Environmental Studies, 28(4), 2243–2251. https://doi.org/10.15244/pjoes/89544	Not about rainwater harvesting
Liu, S., Xia, S., Zhang, X., Cai, X., Yang, J., Hu, Y., Zhou, S., & Wang, H. (2024). Microbial communities exhibit distinct diversities and assembly mechanisms in rainwater and tap-water storage systems. Water Research (Oxford), 253, 121305–121305. https://doi.org/10.1016/j.watres.2024.121305	Single samples only from systems
López-Ballesteros, A., Trolle, D., Srinivasan, R., & Senent-Aparicio, J. (2023). Assessing the effectiveness of potential best management practices for science-informed decision support at the watershed scale: The case of the Mar Menor coastal lagoon, Spain. The Science of the Total Environment, 859(Pt 1), 160144-. https://doi.org/10.1016/j.scitotenv.2022.160144	Simulation only
MacDonald, R. (2001). Providing clean water: lessons from Bangladesh. BMJ, 322(7287), 626–627. https://doi.org/10.1136/bmj.322.7287.626	Editorial, not a research paper, no rainwater harvesting data

Malekinezhad, H., Sepehri, M., Hosseini, S. Z., Santos, C. A. G., Rodrigo-Comino, J., & Meshram, S. G. (2021). Role and Concept of Rooftop Disconnection in Terms of Runoff Volume and Flood Peak Quantity. International Journal of Environmental Research, 15(6), 935–946. https://doi.org/10.1007/s41742-021-00355-9	No water quality samples
Maniam, G., Zakaria, N. A., Leo, C. P., Vassilev, V., Blay, K. B., Behzadian, K., & Poh, P. E. (2022). An assessment of technological development and applications of decentralized water reuse: A critical review and conceptual framework. Wiley Interdisciplinary Reviews. Water, 9(3), e1588-n/a. https://doi.org/10.1002/wat2.1588	review paper only
Mao, J., Xia, B., Zhou, Y., Bi, F., Zhang, X., Zhang, W., & Xia, S. (2021). Effect of roof materials and weather patterns on the quality of harvested rainwater in Shanghai, China. Journal of Cleaner Production, 279, 123419-. https://doi.org/10.1016/j.jclepro.2020.123419	physicochemical quality only
Martinson, B., & Thomas, T. (2009). Quantifying the first-flush phenomenon: effects of first-flush on water yield and quality. In 14th International Rainwater Catchment Systems Conference.	Conference paper only
Marwa, J., Lufingo, M., Noubactep, C., & Machunda, R. (2018). Defeating Fluorosis in the East African Rift Valley: Transforming the Kilimanjaro into a Rainwater Harvesting Park. Sustainability, 10(11), 4194-. https://doi.org/10.3390/su10114194	No water quality data
Melo Neto, M. G. de, Freitas, B. L. S., Fava, N. N. M., & Sabogal-Paz, L. P. (2024). Rainwater treatment system efficiency: Household slow sand filter combined with UVC lamp disinfection. Journal of Water Process Engineering, 58, 104785-. https://doi.org/10.1016/j.jwpe.2024.104785	post tank treatment only, inoculated the rainwater with E coli for testing
Mercer, N., & Hanrahan, M. (2017). “Straight from the heavens into your bucket”: domestic rainwater harvesting as a measure to improve water security in a subarctic indigenous community. International Journal of Circumpolar Health, 76(1), 1312223–1312229. https://doi.org/10.1080/22423982.2017.1312223	water consumption only, no water quality data
Miazga, M. (2012). Creatively green. PM Engineer, 18(4), 16-.	Not peer reviewed, no rainwater harvesting water quality data

Millan, M. I. P., Yanez Pacios, R. T., Garcia, A. C., & Pico, A. S. (2016). Energy Performance Improvement And Cultural Enhancement Of The Andalusian Rural Heritage: Case Study - "El Cortijo Del Fraile." WIT Transactions on the Built Environment, 161, 59–70. https://doi.org/10.2495/ARC160061	No rainwater harvesting water quality data, concept only
Moon, S.-H., Lee, J.-Y., Lee, B.-J., Park, K.-H., & Jo, Y.-J. (2012). Quality of harvested rainwater in artificial recharge site on Jeju volcanic island, Korea. Journal of Hydrology (Amsterdam), 414, 268–277. https://doi.org/10.1016/j.jhydrol.2011.10.041	Chemical water quality only
Moore, T. L. C., & Hunt, W. F. (2013). Predicting the carbon footprint of urban stormwater infrastructure. Ecological Engineering, 58, 44–51. https://doi.org/10.1016/j.ecoleng.2013.06.021	No water quality data
Morales-Figueroa, C., Castillo-Suárez, L. A., Linares-Hernández, I., Martínez-Miranda, V., & Teutli-Sequeira, E. A. (2023). Treatment processes and analysis of rainwater quality for human use and consumption regulations, treatment systems and quality of rainwater. International Journal of Environmental Science and Technology (Tehran), 20(8), 9369–9392. https://doi.org/10.1007/s13762-023-04802-2	review paper only
Mowla, Q. A., & Kabir, S. T. D. (2020). Production of Concrete Using Diverted Rainwater First Flush. IOP Conference Series. Earth and Environmental Science, 581(1), 12027-. https://doi.org/10.1088/1755-1315/581/1/012027	Conference paper
Muftiah Ridjal, A. T., Dewi, C., & Febriany, I. A. (2023). Navigating Clean Water Scarcity: Assessing Household Behaviour of Clean Water Treatment and Storage in Tallo, Makassar. IOP Conference Series. Earth and Environmental Science, 1275(1), 12048-. https://doi.org/10.1088/1755-1315/1275/1/012048	Conference paper and no water quality data
Muktiningsih, S. D., & Putri, D. M. A. R. M. S. (2021). Study of the potential use of rainwater as clean water with simple media gravity filters: A review. IOP Conference Series. Earth and Environmental Science, 733(1), 12147-. https://doi.org/10.1088/1755-1315/733/1/012147	review paper only
Nachshon, U., Ben-Hur, M., Kurtzman, D., Katzir, R., Netzer, L., Gusser, G., & Livshitz, Y. (2021). Dynamic Release of Solutes from Roof Bitumen Sheets Used for Rainwater Harvesting. Water (Basel), 13(24), 3496-. https://doi.org/10.3390/w13243496	physicochemical quality only

Naddeo, V., Scannapieco, D., & Belgiorno, V. (2013). Enhanced drinking water supply through harvested rainwater treatment. Journal of Hydrology (Amsterdam), 498, 287–291. https://doi.org/10.1016/j.jhydrol.2013.06.012	Post-tank treatment only
Naser, A. M., Martorell, R., Narayan, K. M. V., & Clasen, T. F. (2017). First Do No Harm: The Need to Explore Potential Adverse Health Implications of Drinking Rainwater. Environmental Science & Technology, 51(11), 5865–5866. https://doi.org/10.1021/acs.est.7b01886	Viewpoint article, not research
Naus, F. L., Burer, K., van Laerhoven, F., Griffioen, J., Ahmed, K. M., & Schot, P. (2020). Why Do People Remain Attached to Unsafe Drinking Water Options? Quantitative Evidence from Southwestern Bangladesh. Water (Basel), 12(2), 342-. https://doi.org/10.3390/w12020342	No water quality data
Nawaz, M. H., & Baig, M. A. (2018). Domestic three stage water-treatment option for harvested rainwater in water-stressed communities. IOP Conference Series. Materials Science and Engineering, 414(1), 12030-. https://doi.org/10.1088/1757-899X/414/1/012030	Conference paper - review paper
Ndé-Tchoupé, A. I., Nanseu-Njiki, C. P., Hu, R., Nassi, A., Noubactep, C., & Licha, T. (2019). Characterizing the reactivity of metallic iron for water defluoridation in batch studies. Chemosphere (Oxford), 219, 855–863. https://doi.org/10.1016/j.chemosphere.2018.12.065	No rainwater harvesting water quality data
Ndé-Tchoupé, A., Tepong-Tsindé, R., Lufingo, M., Pembe-Ali, Z., Lugodisha, I., Mureth, R., Nkinda, M., Marwa, J., Gwenzi, W., Mwamila, T., Rahman, M., Noubactep, C., & Njau, K. (2019). White Teeth and Healthy Skeletons for All: The Path to Universal Fluoride-Free Drinking Water in Tanzania. Water (Basel), 11(1), 131-. https://doi.org/10.3390/w11010131	No rainwater harvesting water quality data, concept only
Nguyen, D. C., Dao, A. D., Kim, T.-I., & Han, M. (2013). A Sustainability Assessment of the Rainwater Harvesting System for Drinking Water Supply: A Case Study of Cukhe Village, Hanoi, Vietnam. Environmental Engineering Research, 18(2), 109–114. https://doi.org/10.4491/eer.2013.18.2.109	Samples only at one point in the water systems, cannot assess treatment

Nnaji, C. C., Emenike, P. C., & Tenebe, I. T. (2017). An Optimization Approach for Assessing the Reliability of Rainwater Harvesting. Water Resources Management, 31(6), 2011–2024. https://doi.org/10.1007/s11269-017-1630-9	Modeling study only - no water quality data
Nolde, E. (2007). Possibilities of rainwater utilisation in densely populated areas including precipitation runoffs from traffic surfaces. Desalination, 215(1), 1–11. https://doi.org/10.1016/j.desal.2006.10.033	Stormwater harvesting, not rainwater, post-tank treatment
Nosrati, K. (2017). Identification of a water quality indicator for urban roof runoff. Sustainability of Water Quality and Ecology, 9–10, 78–87. https://doi.org/10.1016/j.swaqe.2017.07.001	No microbial water quality data
Oviedo-Ocaña, E. R., Dominguez, I., Ward, S., Rivera-Sanchez, M. L., & Zaraza-Peña, J. M. (2018). Financial feasibility of end-user designed rainwater harvesting and greywater reuse systems for high water use households. Environmental Science and Pollution Research International, 25(20), 19200–19216. https://doi.org/10.1007/s11356-017-8710-5	No rainwater harvesting water quality data, concept only, financial only
Oyebode, O. J., & Umar, A. M. (2024). Design and Modelling of Urban Stormwater Management and Treatment Infrastructure for Communities in Wuse, Abuja. Nature Environment and Pollution Technology, 23(1), 69–86. https://doi.org/10.46488/NEPT.2024.v23i01.005	No microbial data, small prototype of a system using memory foam for filtration
Palawat, K., Root, R. A., Cortez, L. I., Foley, T., Carella, V., Beck, C., & Ramírez-Andreotta, M. D. (2023). Patterns of contamination and burden of lead and arsenic in rooftop harvested rainwater collected in Arizona environmental justice communities. Journal of Environmental Management, 337, 117747–117747. https://doi.org/10.1016/j.jenvman.2023.117747	physicochemical quality only
Pembe-Ali, Z., Mwamila, T. B., Lufingo, M., Gwenzi, W., Marwa, J., Rwiza, M. J., Lugodisha, I., Qi, Q., & Noubactep, C. (2021). Application of the Kilimanjaro Concept in Reversing Seawater Intrusion and Securing Water Supply in Zanzibar, Tanzania. Water (Basel), 13(15), 2085-. https://doi.org/10.3390/w13152085	No water quality data
Peng, Y., Zhang, Z., Yao, J.-J., Zhou, Y., Cai, S., Zhang, J., Li, Y., Kong, Y., & Zhang, W. (2019). Computation fluid dynamics model of first-flush runoff through a hydrodynamic separator. Journal of Cleaner Production, 241, 118253-.	Modeling study only - no water quality data

https://doi.org/10.1016/j.jclepro.2019.118253	
PLUMBING: Rainwater harvesting. (2007). What's New in Building, 70-.	Not a research paper, no rainwater harvesting data
Preeti, P., & Rahman, A. (2021). A Case Study on Reliability, Water Demand and Economic Analysis of Rainwater Harvesting in Australian Capital Cities. Water (Basel), 13(19), 2606-. https://doi.org/10.3390/w13192606	Modeling study only - no water quality data
Professional Gardener - Draw future visitors. (2014). Horticulture Week, 24-.	Not a research paper, no rainwater harvesting data
Qin, Y. (2020). Urban Flooding Mitigation Techniques: A Systematic Review and Future Studies. Water (Basel), 12(12), 3579-. https://doi.org/10.3390/w12123579	review paper
Quaghebeur, W., Mulhern, R. E., Ronsse, S., Heylen, S., Blommaert, H., Potemans, S., Valdivia Mendizábal, C., & Terrazas García, J. (2019). Arsenic contamination in rainwater harvesting tanks around Lake Poopó in Oruro, Bolivia: An unrecognized health risk. The Science of the Total Environment, 688, 224–230. https://doi.org/10.1016/j.scitotenv.2019.06.126	Single sample location only from systems
Quintero Agudelo, A. C., Vargas Terranova, C. A., & Sanabria Alcantar, J. P. (2018). Evaluación de un sistema de fotocatálisis heterogénea y pasteurización para desinfección de aguas lluvias. Ciencia e Ingeniería Neogranadina, 28(1), 117–134. https://doi.org/10.18359/rcin.2350	Studied post-tank treatment only
Quon, H., Allaire, M., & Jiang, S. C. (2021). Assessing the Risk of Legionella Infection through Showering with Untreated Rain Cistern Water in a Tropical Environment. Water (Basel), 13(7), 889-. https://doi.org/10.3390/w13070889	Single samples only from systems
Rao, N. S., Dinakar, A., Sravanthi, M., & Kumari, B. K. (2021). Geochemical characteristics and quality of groundwater evaluation for drinking, irrigation, and industrial purposes from a part of hard rock aquifer of South India. Environmental Science and Pollution Research International, 28(24), 31941–31961. https://doi.org/10.1007/s11356-021-12404-z	Groundwater study

Rattenbury, J. M. (2012). Cistern filtration for rainwater harvesting. PM Engineer, 18(3), 29-.	No water quality data
Rattenbury, J. M. (2012). Cistern management for rainwater harvesting. PM Engineer, 18(6), 16-.	No water quality data
Rattenbury, J. M. (2012). Rainwater harvesting 101. PM Engineer, 18(1), 18-.	No water quality data
Rawan, B., Ullah, W., Ullah, R., Akbar, T. A., Ayaz, Z., Javed, M. F., Din, I., Ullah, S., Aziz, M., Mohamed, A., Khan, N. A., & Khan, O. (2022). Assessments of Roof-Harvested Rainwater in Disctrict Dir Lower, Khyber Pakhtunkhwa Pakistan. Water (Basel), 14(20), 3270-. https://doi.org/10.3390/w14203270	Samples only taken from the tank -- also, only physicochemical data
Rawan, B., Ullah, W., Ullah, R., Akbar, T. A., Ayaz, Z., Javed, M. F., Din, I., Ullah, S., Aziz, M., Mohamed, A., Khan, N. A., & Khan, O. (2022). Assessments of Roof-Harvested Rainwater in Disctrict Dir Lower, Khyber Pakhtunkhwa Pakistan. Water (Basel), 14(20), 3270-. https://doi.org/10.3390/w14203270	Single sample location only from systems
Reyneke, B., Ndlovu, T., Vincent, M. B., Martínez-García, A., Polo-López, M. I., Fernández-Ibáñez, P., Ferrero, G., Khan, S., McGuigan, K. G., & Khan, W. (2020). Validation of large-volume batch solar reactors for the treatment of rainwater in field trials in sub-Saharan Africa. The Science of the Total Environment, 717, 137223–137223. https://doi.org/10.1016/j.scitotenv.2020.137223	Tested a post-tank solar reactor treatment system
Rezende, J. H., & Tecedor, N. (2017). Aproveitamento de água de chuva de cobertura em edificações: dimensionamento do reservatório pelos métodos descritos na NBR 15527. Revista Ambiente & Água, 12(6), 1040–1053. https://doi.org/10.4136/ambi-agua.1940	No water quality data- focused on volume only
Richiardi, L., Pignata, C., Fea, E., Bonetta, S., & Carraro, E. (2023). Are Indicator Microorganisms Predictive of Pathogens in Water? Water (Basel), 15(16), 2964-. https://doi.org/10.3390/w15162964	Not about rainwater harvesting
Sabogal-Paz, L. P., Campos, L. C., Bogush, A., & Canales, M. (2020). Household slow sand filters in intermittent and continuous flows to treat water containing low mineral ion concentrations and Bisphenol A. The Science of the Total Environment, 702, 135078–135078. https://doi.org/10.1016/j.scitotenv.2019.135078	No rainwater quality data -- studied pilot slow sand filters

Sales-Ortells, H., & Medema, G. (2015). Microbial health risks associated with exposure to stormwater in a water plaza. Water Research (Oxford), 74, 34–46. https://doi.org/10.1016/j.watres.2015.01.044	About road runoff, not roofs
Sánchez, A. S., Cohim, E., & Kalid, R. A. (2015). A review on physicochemical and microbiological contamination of roof-harvested rainwater in urban areas. Sustainability of Water Quality and Ecology, 6, 119–137. https://doi.org/10.1016/j.swaqe.2015.04.002	Review paper
Scaramboni, C., Urban, R. C., Lima-Souza, M., Nogueira, R. F. P., Cardoso, A. A., Allen, A. G., & Campos, M. L. A. M. (2015). Total sugars in atmospheric aerosols: An alternative tracer for biomass burning. Atmospheric Environment (1994), 100, 185–192. https://doi.org/10.1016/j.atmosenv.2014.11.003	Not about rainwater harvesting
Schang, C., Schmidt, J., Gao, L., Bergmann, D., McCormack, T., Henry, R., & McCarthy, D. (2021). Rainwater for residential hot water supply: Managing microbial risks. The Science of the Total Environment, 782, 146889-. https://doi.org/10.1016/j.scitotenv.2021.146889	Pilot scale assessment of post-tank treatment only
Segal, A., Khanjar, N., Yang, J., Brooks, K., Williams, M., Little, N., Lazar, A., & Goldstein, R. E. R. (2024). Urban agriculture in Baltimore, Maryland: Documenting current irrigation practices and rainwater harvesting. Urban Agriculture & Regional Food Systems, 9(1). https://doi.org/10.1002/uar2.20075	No water quality data
Senevirathna, S., Ramzan, S., & Morgan, J. (2019). A sustainable and fully automated process to treat stored rainwater to meet drinking water quality guidelines. Process Safety and Environmental Protection, 130, 190–196. https://doi.org/10.1016/j.psep.2019.08.005	Only studied post-tank treatment- actually called stored rainwater raw water
Shammi, M., Rahman, M. M., Bondad, S. E., & Bodrud-Doza, M. (2019). Impacts of Salinity Intrusion in Community Health: A Review of Experiences on Drinking Water Sodium from Coastal Areas of Bangladesh. Healthcare (Basel), 7(1), 50-. https://doi.org/10.3390/healthcare7010050	Review of water quality data only

Silva, G. N. da, Alves, L. D., Santos, I. E. dos, Bila, D. M., Ohnuma Júnior, A. A., & Corrêa, S. M. (2020). An assessment of atmospheric deposition of metals and the physico -chemical parameters of a rainwater harvesting system in Rio de Janeiro Brazil, by means of statistical multivariate analysis. Revista Ambiente & Água, 15(4), 1–31. https://doi.org/10.4136/ambi-agua.2522	physicochemical quality only
Silveira, A., de Lima, J. L. M. P., Abrantes, J. R. C. B., & Mujtaba, B. (2017). Washout of Fine Sand Particles From a Ceramic Tile Roof: Laboratory Experiments Under Simulated Rainfall. Water, Air, and Soil Pollution, 228(9), 1-. https://doi.org/10.1007/s11270-017-3529-8	No microbial water quality data
Singh, S. K., Taylor, R. W., & Su, H. (2017). Developing sustainable models of arsenic-mitigation technologies in the Middle-Ganga Plain in India. Current Science (Bangalore), 113(1), 80–93. https://doi.org/10.18520/cs/v113/i01/80-93	No water quality data - survey only
Slys, D., & Stec, A. (2015). The Analysis of Variants of Water Supply Systems in Multi-Family Residential Building. Ecological Chemistry and Engineering. S, 21(4), 623-. https://doi.org/10.1515/eces-2014-0045	Computational only - no sampling
Soni, P., Dashora, Y., Maheshwari, B., Dillon, P., Singh, P., & Kumar, A. (2020). Managed Aquifer Recharge at a Farm Level: Evaluating the Performance of Direct Well Recharge Structures. Water (Basel), 12(4), 1069-. https://doi.org/10.3390/w12041069	Samples from wells -- though some are fed by rainwater
Stranzl, J. (2005). Mahlum Architects' design proposes greenest building in Olympia School District. Daily Journal of Commerce, 1-.	No water quality data
Sudiajeng, L., Wiraga, I. W., Parwita, I. G. L. M., & Budiadi, I. M. (2020). The effectiveness of horizontal water filtering system on deep rainwater harvesting wells. Journal of Physics. Conference Series, 1450(1), 12029-. https://doi.org/10.1088/1742-6596/1450/1/012029	This paper is examining groundwater recharge from collected rainwater
Technical Brief No11/Rainwater Harvesting. (1987). Waterlines, 5(3), 15–18.	Not a research paper, no rainwater harvesting data
Van Giesen, G. E. (2015). Harvesting rainwater. Plumbing & Mechanical, 33(9), 70–72.	No water quality data, not peer reviewed
Vashisht, A. K., & Aggarwal, R. (2016). Performance of cotton mat as pre-filtration unit for groundwater recharging. Current Science (Bangalore), 111(10), 1591–1595.	Not rainwater harvesting - studied a cotton mat filter with synthetic turbid water

Velumani, P., Mukilan, K., & Manikanda Prabhu, P. (2020). Long term preservation of rainwater for the exploitation of potable water. IOP Conference Series. Materials Science and Engineering, 872(1), 12116-. https://doi.org/10.1088/1757-899X/872/1/012116	Conference paper and unable to calculate log reductions from the data
Velumani, P., Mukilan, K., & Manikanda Prabhu, P. (2020). Long term preservation of rainwater for the exploitation of potable water. IOP Conference Series. Materials Science and Engineering, 872(1), 12116-. https://doi.org/10.1088/1757-899X/872/1/012116	Conference paper
Vianello, M., Vischetti, C., Scarponi, L., & Zanin, G. (2005). Herbicide losses in runoff events from a field with a low slope: Role of a vegetative filter strip. Chemosphere (Oxford), 61(5), 717–725. https://doi.org/10.1016/j.chemosphere.2005.03.043	Not about rainwater harvesting
Wang, W. P., Zhou, Y. Q., & Deng, H. Y. (2012). Pre-Treatment of Karst Groundwater Recharge with Roofwater System. Applied Mechanics and Materials, 212–213, 307-. https://doi.org/10.4028/www.scientific.net/AMM.212-213.307	Used zeolite filter and only looked at ammonia removal
Wang, Z., Qi, F., Liu, L., Chen, M., Sun, D., & Nan, J. (2021). How do urban rainfall-runoff pollution control technologies develop in China? A systematic review based on bibliometric analysis and literature summary. The Science of the Total Environment, 789, 148045–148045. https://doi.org/10.1016/j.scitotenv.2021.148045	Review paper
Waseem, M., Mutahir Ullah Ghazi, S., Ahmed, N., Ayaan, M., & Kebede Leta, M. (2023). Rainwater Harvesting as Sustainable Solution to Cope with Drinking Water Scarcity and Urban Flooding: A Case Study of Public Institutions in Lahore, Pakistan. CivilEng, 4(2), 638–656. https://doi.org/10.3390/civileng4020037	No water quality data
Wells, S., & Ervin, D. E. (2007). Academia embraces Green. Campus Facility Maintenance, 4(3), 28-.	No water quality data
Wilbers, G.-J., Sebesvari, Z., & Renaud, F. G. (2014). Piped-Water Supplies in Rural Areas of the Mekong Delta, Vietnam: Water Quality and Household Perceptions. Water (Basel), 6(8), 2175–2194. https://doi.org/10.3390/w6082175	No rainwater harvesting quality data
Yin, H.-B., & Patel, J. (2018). Comparison of methods to determine the microbial quality of alternative irrigation waters. Agricultural Water Management, 201, 38–45. https://doi.org/10.1016/j.agwat.2018.01.012	Data only at one point from RWH systems

Zdeb, M., Zamorska, J., Papciak, D., & Słyś, D. (2020). The Quality of Rainwater Collected from Roofs and the Possibility of Its Economic Use. Resources (Basel), 9(2), 12-. https://doi.org/10.3390/resources9020012	roof runoff - not rainwater harvesting
Zhao, X., Feng, J., Xiao, M., Shen, D., Tan, C., Song, X., Feng, J., Duley, W. W., & Zhou, Y. N. (2021). A Simple High Power, Fast Response Streaming Potential/Current-Based Electric Nanogenerator Using a Layer of Al2O3 Nanoparticles. ACS applied materials & interfaces, 13(23), 27169–27178. https://doi.org/10.1021/acsami.1c04290	Not about rainwater harvesting
Zhao, Y., Wang, X., Liu, C., Wang, S., Wang, X., Hou, H., Wang, J., & Li, H. (2019). Purification of harvested rainwater using slow sand filters with low-cost materials: Bacterial community structure and purifying effect. The Science of the Total Environment, 674, 344–354. https://doi.org/10.1016/j.scitotenv.2019.03.474	Filtration using slow sand filter as post-tank treatment
Zheng, L., & Deng, Y. (2024). Advancing rainwater treatment technologies for irrigation of urban agriculture: A pathway toward innovation. The Science of the Total Environment, 916, 170087–170087. https://doi.org/10.1016/j.scitotenv.2024.170087	Review paper
Zhu, K., Zhang, L., Hart, W., Liu, M., & Chen, H. (2004). Quality issues in harvested rainwater in arid and semi-arid Loess Plateau of northern China. Journal of Arid Environments, 57(4), 487–505. https://doi.org/10.1016/S0140-1963(03)00118-6	Single sample location only from systems