Microbiological quality of roof-harvested rainwater and health risks: a review

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Abstract

Roof-harvested rainwater (RHRW) has been considered an effective alternative water source for drinking and various nonpotable uses in a number of countries throughout the world. The most significant issue in relation to using untreated RHRW for drinking or other potable uses, however, is the potential public health risks associated with microbial pathogens. This paper reviews the available research reporting on the microbial quality of RHRW and provides insight on the capacity of fecal indicator bacteria to monitor health risks and disease outbreaks associated with the consumption of untreated RHRW. Several zoonotic bacterial and protozoan pathogens were detected in individual and communal rainwater systems. The majority of the studies reported in the literature assessed the quality of rainwater on the basis of the presence or absence of specific pathogens, with little information available regarding the actual numbers of such pathogens. In addition, no information is available concerning the ongoing prevalence of different pathogens in RHRW over time. The published data suggest that the microbial quality of RHRW should be considered less than that expected for potable water and that the commonly used indicators may not be suitable to indicate the presence of pathogens in RHRW. Several case control studies established potential links between gastroenteritis and consumption of untreated RHRW. Therefore, health risks assessment models, such as those using Quantitative Microbial Risk Assessment, should be used to manage and mitigate health risks associated with drinking and nonpotable uses of RHRW.

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with Pathogenic Escherichia coli Strains Isolated from Domestically Harvested Rainwater during Low- and High-Rainfall Periods

Applied and Environmental Microbiology 2014 80:5

Comparative Human Health Risk Analysis of Coastal Community Water and Waste Service Options

Environmental Science & Technology 2014 48:16

Evaluation of harvested rainwater quality at primary schools of southwest coastal Bangladesh

Environmental Monitoring and Assessment 2019 191:2

Comparison of methods to determine the microbial quality of alternative irrigation waters

Agricultural Water Management 2018 201

Irrigation water quality and microbial safety of leafy greens in different vegetable production systems: A review

Food Reviews International 2018 34:4

Critical insights for a sustainability framework to address integrated community water services: Technical metrics and approaches

Water Research 2015 77

Microbiological Values of Rainwater Harvested in Adelaide

Pathogens 2018 7:1

Dilemma of roof rainwater quality: applications of physical and organic treatment methods in a water scarce region of Mekelle, Ethiopia

Urban Water Journal 2017 14:5

Effect of first-flush device, roofing material, and antecedent dry days on water quality of harvested rainwater

Environmental Science and Pollution Research 2017 24:27

Microbial source tracking markers associated with domestic rainwater harvesting systems: Correlation to indicator organisms

Environmental Research 2018 161

Efficiency of a closed-coupled solar pasteurization system in treating roof harvested rainwater

Science of The Total Environment 2015 536

Evaluation of three full-scale stormwater treatment systems with respect to water yield, pathogen removal efficacy and human health risk from faecal pathogens

Science of The Total Environment 2016 543

Microfluidic quantification of multiple enteric and opportunistic bacterial pathogens in roof-harvested rainwater tank samples

Environmental Monitoring and Assessment 2018 190:2

Antibiotic resistance in Escherichia coli isolates from roof-harvested rainwater tanks and urban pigeon faeces as the likely source of contamination

Environmental Monitoring and Assessment 2015 187:7

Occurrence of Intestinal and Extraintestinal
Virulence Genes in Escherichia coli Isolates from Rainwater Tanks in Southeast Queensland, Australia
Applied and Environmental Microbiology 2011 77:20

Quality of Roof-Harvested Rainwater as a Function of Environmental and Air Pollution Factors in a Coastal Mediterranean City (Haifa, Israel)
Water 2017 9:11

The presence and prevalence of Legionella spp in collected rainwater and its aerosolisation during common gardening activities
Perspectives in Public Health 2018 138:5

Domestic Rainwater Harvesting: Microbial and Chemical Water Quality and Point-of-Use Treatment Systems
Water, Air, & Soil Pollution 2013 224:7

Development and small-scale validation of a novel pigeon-associated mitochondrial DNA source tracking marker for the detection of fecal contamination in harvested rainwater
Science of The Total Environment 2018 615

Survey of Rainwater Catchment Use and Practices on Hawaii Island
Journal of Contemporary Water Research & Education 2017 161:1

Storage-induced deterioration of domestic water quality
Journal of Water, Sanitation and Hygiene for Development 2019

Self-cleaning filtration: A novel concept for rainwater harvesting systems
Resources, Conservation and Recycling 2013 78

Health Hazards Associated with Consumption of Roof-Collected Rainwater in Urban Areas in Emergency Situations
International Journal of Environmental Research and Public Health 2016 13:10

Metagenomic Characterization of Airborne Viral DNA Diversity in the Near-Surface Atmosphere
Journal of Virology 2012 86:15

The research-policy nexus in climate change adaptation: experience from the urban water sector in South East Queensland, Australia
Regional Environmental Change 2014 14:2

Analytic Modeling of Rainwater Harvesting in the Brazilian Semiarid Northeast
JAWRA Journal of the American Water Resources Association 2016 52:1

Corn starch-based treatment improves rainwater quality

Rainwater harvesting in American Samoa: current practices and indicative health risks
Environmental Science and Pollution Research 2017 24:13

From Rain Tanks to Catchments: Use of Low-Impact Development To Address Hydrologic Symptoms of the Urban Stream
Roof-harvested rainwater is an alternative water source. Though generally considered acceptable for potable use, the presence of pathogens has been reported in research literature. Various zoonotic pathogens are present in faeces of animals that have access to the roof and, following rain events, pathogens may be transported to rainwater tanks via roof runoff. In this study, the microbiological quality of roof-harvested rainwater was assessed by enumerating faecal indicators and detecting zoonotic pathogens in samples from rainwater tanks. The significance of this study stems from the fact that, instead of measuring faecal indicators, pathogens that are capable of causing illness were directly measured using quantitative PCR (qPCR) methods.

Conclusions: The microbial quality of 'improved' water sources in our study area was not maintained at the point of consumption, possibly due to a combination of mixing water sources at the household level, unsafe storage and handling practices, and inadequately treated piped-to-plot water. These results have implications for refining international targets for safe drinking water access as well as the assumptions underlying global burden of disease estimates, which posit that 'improved' sources pose minimal risks of diarrhoeal diseases.

Roof-harvested rainwater can become contaminated from a range of sources. Recent studies conducted in Queensland have found evidence that rainwater tanks are often contaminated with animal faeces. Animal faeces can contain a range of microorganisms, such as bacteria, viruses and protozoa, some of which can cause human disease. The supply of rainwater to hot water systems may result in the system corroding faster than normal, due to the slightly acidic quality of rainwater and softness. Advice should always be sought from the system supplier before using rainwater for this purpose. Queensland Health does not recommend the use of water from the hot water tap for drinking or food preparation.