Health risk assessment in occupational settings during non-potable use of harvested rainwater

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Introduction: Water scarcity is becoming prevalent worldwide due to factors such as rapid population growth particularly in urban areas, drought and climate change. This has led to a growing interest in water reuse. Rainwater harvesting (RWH) is considered a cost effective strategy for non-potable purposes including car washing, landscape irrigation, toilet flushing, showering and laundering of clothes. However, harvested rain water (HRW) can contain pathogens including members of the genus *Salmonella* spp., *Campylobacter* spp., pathogenic *Escherichia coli*, *Klebsiella* spp., *Legionella* spp., *Mycobacterium* spp., *Pseudomonas* spp. and *Staphylococcus* spp. This can present significant microbiological health risks to exposed individuals particularly in occupational settings.

Objectives: To conduct a walk through survey of the sites, to determine the microbiological quality of HRW, to determine the occurrence and concentration levels of specific pathogens in HRW, to look at shifts in the microbial community structure of stored rainwater (RW), to evaluate potential occupational exposure to microbiological contaminants in HRW at selected reuse sites using epidemiological cross- sectional surveys, to estimate the burden of disease by exposure to pathogens found in HRW using quantitative microbial risk assessment, and to provide guidance to facility managers regarding maintenance of RW storage tanks to ensure the water is fit for purpose.

Materials and methods: The study design will entail environmental assessment to identify microbial hazards, epidemiological surveys to assess potential health risks, and a quantitative microbial health risk assessment (QMRA) to estimate burden of disease. We have thus far identified two sites where workers use RW. One of the sites is an insurance company in Johannesburg where workers use RW for toilet flushing, car washing, irrigation and ornamental water features. The other site is a manufacturing company in Pretoria where RW is used by workers to shower. The sample types will be bulk water samples taken from the outlet point at the RW tanks over a period of four weeks and analysed for total coliforms and *Escherichia coli* using the IDEXX Colilert-18, and enterococci using the Enterolert commercially available test kits as per manufacturer's instructions. Although the reliability of indicator organisms such as *E. coli* as a health based indicator for monitoring RW quality has been questioned due to their poor correlations with pathogens, they still prove useful in assessing changes in water quality. Molecular tests using genus and species specific primers will be performed to detect and quantify the concentrations of pathogens of interest using quantitative polymerase chain reaction. The target pathogens will be based on literature on what has been found in RW tanks as well as

taking into consideration the possible exposure scenarios at the site, and the possibility of a health risk to the worker. Some possible target organisms are *Salmonella enterica* and *Campylobacter jejuni* which are enteric pathogens, and *Legionella pneumophila* a respiratory pathogen. Sequencing using PacBio platform will be conducted at the Sequencing Facility at Inqaba Biotec. The results will be used to determine possible shifts in the community structure during storage of the water over the period of study. An attempt will also be made to compare the results with traditional quality indicators. The human health risk assessment will consist of an epidemiological study, and QMRA. The epidemiological study will consist of an interview based questionnaire which will include questions on symptoms related to selected health risk outcomes e.g. respiratory and skin, work activities in current employment using RW, duration of work activity, use of personal protective equipment (PPE), and hand hygiene practices. This will require ethics approval and a signed consent from the workers at the RW use sites. The second part of health risk assessment will involve QMRA.To establish a QMRA process for estimating the human health risk associated with defined scenarios involving exposure to specified pathogens, a four-step process is commonly employed. The four steps represent hazard identification, exposure assessment, dose-response assessment and risk characterization. The resulting predicted risk will then be compared to a health benchmark or 'acceptable' risk of infection and reported as probability of infection (illness).

Discussion: Studies in South Africa have looked at the pathogens present in HRW but studies looking at the health risks of RW during non-potable use in an occupational setting do not exist. With the increasing demand for alternative water sources, research focusing on the human health risks of RW is critical to ensure safe use for non-potable purposes in occupational settings. A better understanding and increased awareness of the occupational health risks can enable improved management steps to be taken to minimise exposure and protect workers' health. Our findings will contribute to informing policy and decision making on the appropriate PPE for workers conducting various activities at RW use sites.