TECHNICAL BRIEF

August 2017
The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

Evaluating the risks of use of water from rooftop rainwater harvesting

A Water Research Commission (WRC) study has been completed on evidence-based approach to measuring the costs and benefits of changes in aquatic ecosystem services.

Background

South Africa has a mixture of developed and developing regions, with at least 9.7 million people that do not have access to water supplies of adequate quality. Rooftop rainwater harvesting (RRWH) is considered to be one of the most promising alternatives for supplying freshwater in the face of increasing water scarcity and escalating demand.

Although rainwater harvesting is being practiced in a number of areas, the technology is not fully utilised in rural communities. Rainwater harvesting can provide water directly to households, including those in rural and peri-urban areas where conventional technologies cannot supply adequate volumes for domestic purposes.

Although the general perception is that water from rooftop-harvested rainwater is safe to drink, the presence of potential pathogens and enteric viruses have been reported in these water sources.

The overall aim of this project was to evaluate the risks associated with the use of RRWH for domestic use and in homestead food gardens, and groundwater for potable use and livestock watering.

Figure 1 – A typical rooftop rainwater harvesting system.

Prevalence of faecal indicators

A total of 365 water samples from three boreholes, five ground harvested rainwater tanks, five rivers, 80 roof-harvested rainwater tanks, and one spring were collected. Sample collection was further divided into early (October to December) and late (January to March) rain season.

Water quality was evaluated based on ***E.coli*** coliforms and ***enterococci*** detection. In RRWH ***E.coli*** were detected in 44.1% of the samples, ***Enterococcus*** in 57.9% and faecal coliforms in 95.7% of the samples.

The most prevalent concentration of ***E. coli*** (29.1%) and enterococci (19.5%) were within 1-10 cfu/100 mℓ, whereas those for faecal coliforms (36.6%) were within 100-1000 cfu/100 mℓ. Evaluation of the microbial quality of river water used by the villagers as an alternative water source revealed that 79% tested positive for ***Enterococcu***s, 39% for ***E. coli,*** and all samples for faecal coliforms.

The majority of the samples that tested positive for ***Enterococcus*** (32%) and ***E. coli*** (16%) had a concentration of 10-100 cfu/100 mℓ. However, the majority of the concentrations for faecal coliforms detected (48%) were of concentrations greater than 1000 cfu/100 mℓ.

Furthermore, the microbiological quality of rainwater harvested from rooftops and surfaces runoff was evaluated based on the concentrations of ***E. coli,*** faecal coliforms, enterococci and ***Pseudomonas aeruginosa.*** Samples were collected from fifteen RRWH tanks. On average, ***E. coli*** and ***enterococci*** were detected in 44.8% of the RRHW tanks although ***enterococci*** concentrations were several times higher than those for ***E. coli.***

Detection of pathogens

Real-Time PCR evaluation of the prevalence of pathogenic bacteria and specific virulence genes in harvested rainwater was carried out on a total of 168 samples from Jericho (86), Ntembeni (28), Ga-Molepane (37), and Port St Johns (17). Samples were analysed for the presence and absence of ***Shigella*** spp., ***Salmonella*** spp. and ***E. coli*** virulence genes (***stx1, stx2*** and ***eaeA***). All the samples tested negative for the ***Shigella*** spp. ipaH gene, while five tested positive for ***Salmonella*** ipaB gene. None of the samples tested positive for the stx1 and stx2 genes, and only two tested positive for the ***eaeA*** gene.

Guidance information and recommendations for use of rooftop rainwater harvesting water storage tanks

A number of factors affect RRWH quality, including chemical and microbial contamination. RRWH is generally used directly without prior treatment, which exposes people to potential health risks. Contamination of RRWH rainwater is mainly due to dust and faecal material present on the catchment surface.

The potential for microbial hazards in potable water to affect consumers are dependent on the barriers that are in place. These start with the prevention of contamination at source and at various stages thereafter, including storage and distribution.

It is therefore vital that appropriate guidelines are available to ensure that the potential health risks associated with the use of RRWH are minimised, while the benefits are maximised.

A systematic approach on the use of microbial risk assessment (MRA) as a tool for the management of health risks associated with harvested rainwater (HRW) was used to compile guidelines and the use of RRWH. Implementation of the MRA process was undertaken as a systematic approach to determine the level of potential health risk associated with microbial pathogens in HRW for potable or non-potable purposes.

Predetermined health targets were set in the MRA to achieve a degree of public health protection. Investigations into the microbial quality of RRWH have revealed a wide range of contamination factors which vary among specific areas, sites and catchment systems.

Due to the intricate and dynamic nature of the system, it was necessary to weigh each contaminant factor individually in the construction of the guidelines. This will bring about effective management and mitigation of health risks associated with potable uses of RRWH.

The guidelines therefore identify critical practices or points of concern that may serve as a source of contamination and suggest the appropriate mitigation strategies to minimise adverse health effects.

Conclusions

The following conclusions can be drawn from this study:

- Although RRWH does not represent a significant percentage of water used for domestic purposes in South Africa, it remains an important water source that is basically fit for purpose given its use in the context of an effective management framework.

- The contamination of RRWH is strongly influenced by environmental settings especially in the presence of faecal sources in the form of animals roaming near dwellings or where birds frequent rooftops. While little can be done to eliminate the presence of faecal sources around rural homesteads, practising good animal husbandry and ensuring appropriate RRWH maintenance systems can minimise levels of contamination. This should also include systematic cleaning of the roofs and gutters especially before annual rainfall events.

- Although significant levels of microbial contamination can be detected in some RRWH, certain levels of indicator bacterial present may be tolerated. However, tolerable levels of contamination will depend on water use and can only be established where good rainwater harvesting practices are being implemented. That is, after all has been done to harvest clean rainwater, contaminant levels detected in the water may be what is normal for the area.

- Since the presence of pathogens cannot be correlated to faecal indicators in RRWH, it is recommend that a system based on the dual prevalence of ***E. coli*** and enterococci as sanitary indicator bacteria be introduced. Further research should focus on establishing the parameters for ***E. coli*** and enterococci dual use to show levels of contamination and potential health risk as applied to stored harvested rainwater.

- Biofilms can develop in both untreated and treated

water sources on the interior of low density polyethylene water storage tanks as early as one day after collection. However the storage period and the microbial quality of the source water influences water quality deterioration and the rate of biofilm formation. Biofilm development is further enhanced by crevices in the interior surface of storage tanks. Effective management of biofilms in water storage systems is thus critical as part of a basic RRWH quality management plan.

- Given the lack of standards, knowledge regarding the level of contamination and different types of RRWH systems and settings there is a need to propose a guidance document that can provide information on risks associated with harvesting rainwater and best management practices. The guidance information should also give a description of the chemical and biological constituents that can potentially affect water quality, their occurrence in the harvested water interdependence with other constituents, and their properties. These should also include standardised methods for measurement. For each contaminant, the guidance information on risks that are site-specific should also be provided in addition to generic guidance information for best RRWH practices. While the guidance information may not be completely accurate, it should provide improvement over the current non-specific systems. The information should allow users to obtain information on risks more easily by explaining RRHW sampling procedures and how to interpret the results according to the RRWH system, general environment, and site or homestead specific factors. This guidance information more specifically should stipulate the targeted water quality range in which infection or adverse effects are unlikely to occur. Current data gathered mainly from Australia suggests that even when concentrations are over the upper safety limit and are likely to result in infection, diseases may not always develop in the prevailing community.

- The response to risks depend on site-specific factors, synergistic and antagonistic interactions between food and water contaminants, the age of the person, and the actual water intake that determines the ingestion rate of the contaminant. However, a precise way to evaluate the risk has limitations in that tools to measure RRWH specific factors may not be easily available. In this case, impact factors may have to be estimated, making it still precarious. Given this scenario, an interactive water quality guideline in the form of a computer software system that would have programmed references, by which risk assessment could be done for a specific RRWH system, environment, site or homestead specific factors and extent of exposure, should be developed.

Related reports:
Evaluation of the risks associated with the use of rooftop rainwater harvesting and groundwater for domestic use and livestock watering Volume 1 (**Report No. 2175/1/16**) and *Volume 2* (**Report No. 2175/2/16**). Contact Publications at Tel: (012) 761 9300; Email: orders@wrc.org.za or Visit: www.wrc.org.za