Assessment of the Suitability of Rainwater as a Drinking Water

T. Vithursan, S.H.M. Zammil, R.Weerasooriya

Abstract: Many kinds of research are being conducted to install a rooftop rainwater harvesting system as an alternative water source. In this study, social assessment and quality assessment were assessed. Water samples were collected from rainwater harvesting Tanks in the Kurunegala district. Accordingly, two visits were conducted in the study area for sample collection during the dry season. The test water quality results were compared with the Sri Lankan drinking water standard (SLS 614: 2013). Furthermore, the social assessment was done through questionnaires—most physicochemical quality parameters aligned with the Sri Lankan drinking water standard. However, one tank was contaminated with 17 CFU/100 ml Total coliform and 11 CFU/100 ml *E. coli* contamination. Ferro cement tank samples had EC, Turbidity, Alkalinity and Hardness values higher than the plastic tank samples but also in line with SLS standard. The average value of hardness was increased on the second visit. According to the questionnaire, improper maintenance of the first flush system was identified. Moreover, the consumers are satisfied with the quality of rainwater. Only 30.8% of users consume the water after boiling it. Therefore, rainwater is a good solution for the people in the dry zone areas to fulfil their drinking water requirements.

Keywords: Rainwater harvesting; Drinking water; Rainwater quality

1. Introduction

Every day, the world's access to potable water decreases. As a result, individuals began to look for suitable alternative means to meet their water needs. Rainwater collection is one alternative resource that piqued people's interest. (Campisano *et al.*, 2017). It has also become an essential supply of water in developing countries.

The basic components of a rainwater harvesting system are the roof surface (catchment), storage tank, and conveyance system (gutters). The storage tank is the most important part of any RWH (Rain Water Harvesting) system. It enables the implementation of basic storage and treatment functions. Most of the time, the catchment is a roof surface, although other impermeable surfaces can also be used to collect water. The gathered rainwater is then transported from the catchment to the

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storage tank via gutters and down spurs. To control the quality of the water, first flush diverters, screens, and filters are used in contrast to these fundamental components.

Water quality is determined by the quality of the source as well as contamination exposure during collection, treatment, and storage. In contrast to biological quality, the chemical and physical quality of captured rainwater were found to be within acceptable limits in many cases documented in the literature. However, they exhibit increasingly acidic features when the pH value ranges from 4.5 to 6.5, and the pH value rises over time Furthermore, cations such as sodium, calcium, and potassium, as well as anions such as chloride, nitrate, and sulfate, were found in a variety of investigations conducted around the world. Even from that, heavy metals are regarded as a significant pollutant in rainwater.

2. Literature Review

2.1 Microbial quality of harvested rainwater.

The location of the RWH system, the climate in the area, the presence of a first flush mechanism, and the sort of wild life in the area can all be regarded as key contributors to microbial contamination. Pathogens are primarily transmitted by birds, however dry or wet deposition can also be a cause of pollution (Campisano *et al.*, 2017). Because it increases the amount of animal feces deposited on the roof surface, the length of the dry season can also be regarded as a governing factor for microbiological contamination.

2.2 Physico-chemical quality

Rainwater meets drinking water criteria in terms of physical and chemical quality, according to numerous studies. Rainwater tends to be more acidic in most cases. As a result, several studies reveal that rainfall pH levels are significantly lower. In rainfall, pH levels typically vary from 4.5 to 6.5, and they rise over time (Lee *et al.*, 2017). Electrical conductivity, TDS, and turbidity of rainwater are generally within the drinking water guidelines (Lee *et al.*, 2017).

3. Materials and Methods

Kurunegala district was selected as study area. Polpithigama GN division was selected which is situated in Kurunegala district. The area was selected to as it has the highest number of rainwater harvesting tanks according to the data collected by the National Water Supply and Drainage Board, Kurunegala. Polpithigama has the highest number of RWH systems among the other GN divisions. In Polpithigama GN division, Ulpotha area was selected for this study. Fourteen samples were collected randoml.

3.1 Questionnaire surveys

Questionnaire surveys were conducted from consumers where RWH samples were collected. Questionnaire survey was done to the RWH systems users. 15 systems (5000 L) were selected from the Polpethigama GN division. Questionnaires were filled by interviewing the households and by observing the rainwater harvesting system.

3.2 Water quality analysis

Water samples were collected from each RWH system from that location. Two visits were conducted in the study area. In the first visit, 15 samples were collected, and in the second visit, 14 samples were collected from the same tanks. During the second visit, it was noted that one tank has been totally destroyed by the users. Hence, for the water quality analysis relevant to the second visit, only 14 samples were considered.

4. Results and Discussion

4.1 Water quality analysis

The SLS standard has fixed the EC value to be less than 750 µS/cm in drinking water (SLS 1983). So, it can be seen that the EC values were within the SLS standards for all the samples. In visit 1, the average EC value of plastic tank samples was 41.45 µS/cm and the average EC value of ferro cement tank samples was 166.57 µS/cm. In the second visit, the average EC value of plastic tank samples was 41.97 µS/cm and the average EC value of ferro cement tank samples was 1153.43 µS/cm. In two visits, the ferro cement tank samples had an EC value higher than the plastic tank samples. There is not much variation in the EC between visits, but the EC value on the second visit is higher than the first visit value in the RW 11th sample, because the user of that particular rainwater system did not clean the roof and did not do the first flush the system when they fill it.

The SLS standard for drinking water Turbidity is 2NTU (Sri Lanka standards for potable water – SLS 614, 2013). The

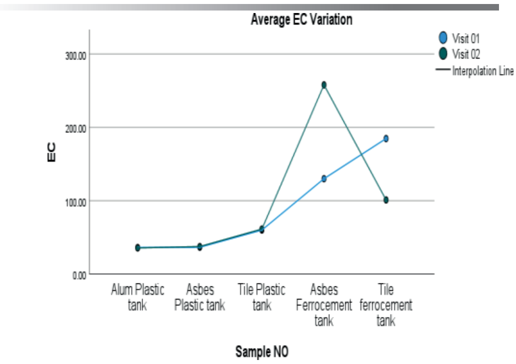

Figure 1: Graph of the variation of different type RWH tanks

turbidity values of all 14 samples were within the acceptable range. On first visit, the average turbidity value of ferro cement tanks is 0.71, which is greater than the average turbidity value of plastic tanks, which is 0.36. The average value of all 14 samples is 0.43, as well as in the second visit, the average turbidity value of ferro cement tanks is 0.93, which is greater than the average turbidity value of plastic tanks, which is 0.26. The average value of all 14 samples is 0.41, and those are within the acceptable range of the SLS standard for drinking water. The samples collected from ferro cement show a higher average turbidity than those from plastic tank samples due to the dissolving of the material in

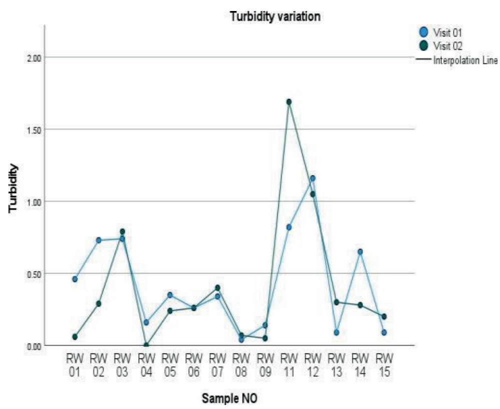

Figure 2: Graph of the variation of turbidity result in polpithigama GN division

rainwater. The ferro cement tank samples show the maximum value of alkalinity in two visits, but these values are also under the SLS standard. Not much variation was obtained in the plastic tank system, while ferro cement tank system showed the variation of lower average values than the first visit, which may be due to the collection of new water.

The SLS standard has fixed the alkalinity value to be less than 200 mg/l as CaCO3 in drinking water (Sri Lanka standards for potable water – SLS 614, 2013). The obtained alkalinity values from various studies were within the relevant standards. In the first visit, the average alkalinity value of plastic tank samples was 20.89 mg/l as CaCO3 and the average alkalinity value of ferro cement tank samples was 65.60 mg/l as CaCO3. In the second visit, the average alkalinity value of plastic tank samples was 22.00 mg/l as CaCO3 and the average alkalinity value of ferro cement tank samples was 80.17 mg/l as CaCO3. The obtained alkalinity values from various studies were within the relevant standards. In two visits, results obtained in the study show low values. But the average alkalinity values vary between each system. Samples collected from the plastic tank system aluminum sheet roof record the lowest alkalinity value, while the alkalinity values obtained from asbestos are greater than the aluminum roof system. The alkalinity value of the tile roof system of the plastic tank was higher than that of the aluminum and asbestos roof systems. Samples collected from Ferro cement tanks show the highest among all. Not much variation was obtained in the plastic tank system, while ferro cement tank system showed the variation of lower average values than the first visit, which may be due to the collection of new water.

The ferro cement tank samples show the maximum value of hardness in two visits due to dissolving material into collected rain water. Figure 1 shows the average hardness variation of different types of RWH tanks between two visits. In all kinds of roofs and tanks, there can be a variation observed between two visits. The average value of hardness was increased on the second visit in all types of tanks due to the new rain water.

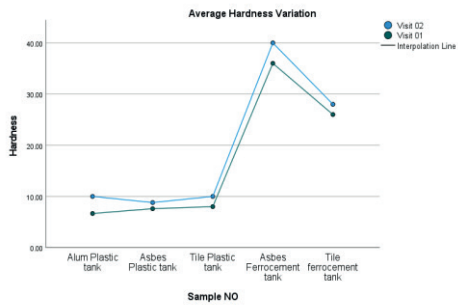

Figure 3: Graph of the average hardness variation of different type RWH tanks between two visits

According to the anion result of 14 water sample analysis of two visits, all tested anion results lies within the acceptable range with respect to portable water quality standard in Sri Lanka (Sri Lanka standards for potable water – SLS 614, 2013). Those anions are Chloride, Nitrate and Sulphate.

It can be seen that 13 of the samples comply with the SLS standard. And one sample is higher than the SLS drinking water standard level. The main reasons for the biological contamination of that tank were that the lid was not covered properly and the inlet point of the tank didn't have any lid.

4.2 Questionnaire

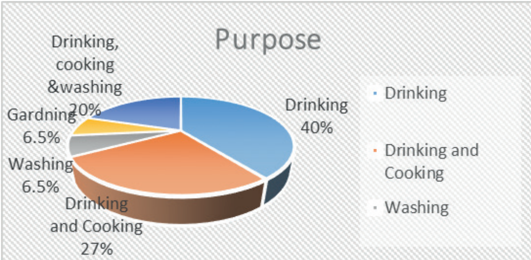

Figure 4: The chart of the purpose of harvested rainwater

40% of the users use the water only for drinking purposes. And 27% of the users use them for drinking and cooking purposes, while 20% use them for drinking, cooking, and washing purposes. 6.5% of users use it for only washing, while 6.5% of users use it for only gardening purposes

Once the tank is filled completely, the capacity of the tank is enough to cater to the drinking water requirements throughout the year. More than 90% of the users who use rainwater for drinking were able to use the rainwater for 6–8 months, but it varies with the rainfall. Some users were unable to fill up the tanks to their full capacity due to a lack of sufficient rainfall. Also, due to the first flush, they waste a considerable amount of water.

4.2.1 Operational and Maintenance process

Users who use rainwater often clean their systems at least once a year before the start of the rainy season. 60% of the users clean the catchment surface (roof) and gutter system before the start of the rainy season, and they flush away the water for few days during the early stages of the rainy season, while others just use the first flush to clean the roof and the gutters. All the users clean the tank before filling it up with new water.

The filter is placed on top of the tank inlet. So many users remove the filter unit from the RWH system. Users complain that the current filtering system is not efficient and a huge amount of rainwater is wasted during a high rain event. Some users use clothes as a filter on the outlet tap.

Another disadvantage of the current RWH is the improper first flush method. Currently, the RWH users flush away water at least for five days. Due to that, people waste a huge amount of rainwater. Some were unable to fill the tank to its full capacity due to this reason. But in some countries, there is a standard amount of first flush for RWH systems. Generally, after the first 2 mm of rainfall, the concentration of contaminants reduces and becomes constant (Meera and Ahammed, 2006). The first flush systems were designed with a first flush volume of 15–20 liters. For Sri Lanka, no such standard amount of first flush volume has been defined. 60% of users removed their down pipes. The reason was due to the deformation of pipes due to heat. People who experienced that issue suggested designing a system with an easy method to remove the down pipe and fix it when needed.

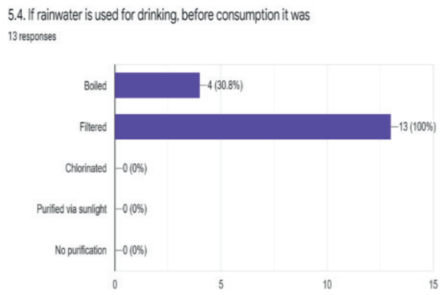

Figure 5: The chart of the treatment before consumption

None of them are using any disinfection method before consuming the rainwater. Only 30.8% of users consume the water after boiling, while others consume rainwater even without boiling. It may be risky as to the bacteriological quality. 26.7% of the RWH lid has been damaged or is not in proper maintenance. Due to that, contamination can occur. Some kind of contamination can be reported in some RWH tanks.

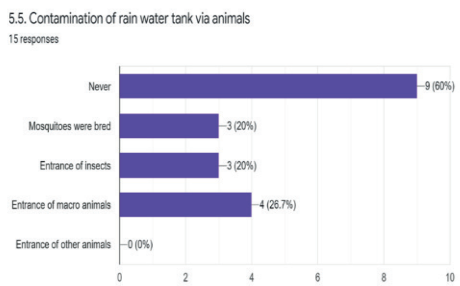

Figure 6: The chart of contamination of rain water tank via animals.

20% of RWH tanks reported mosquito breeding and 20% of RWH reported the entrance of macro insects as well. Macro animals can be entrance 26.7% of tanks.

5. Conclusions

5.1 Questionnaire

It can be seen that most of the people in the dry zone areas are using rainwater as their main drinking source. Since the prevailing water in the area is always unreliable and most sources are situated a long distance away, people prefer to use rainwater. The majority of the users use rainwater only for drinking and cooking purposes. Due to that, they were able to consume the water throughout the dry season.

But there are some operational and maintenance issues with those systems. In most RWH systems, the first flush unit is not maintained correctly. According to the users, a considerable amount of water is wasted during heavy rains. But some users do not clean the roof; they use the first flush to clean the roof. They believe the water must wash away for a few days until the roof is cleaned. Since there is no proper study on the first flush in Sri Lanka, it is not advisable to change the current method. The roof usage is much lower, and due to the improper first flushing method in the RWH systems, it takes longer to fill up the tank to its full capacity. Some users could not fill the tank without insufficient rainfall during the rainy period. Also, people with reliable and good-quality water sources are reluctant to use the RWH systems as their main drinking water source. Need to improve the current filter system as the wastage of water is much higher in the present filtering systems.

5.2 Water quality

The obtained results show that the pH value of the majority of the samples shows acceptable pH values. Even though there is a significant pH variation between the systems, the newly collected rainwater shows a lower pH value than the first visit.

The electrical conductivity of the samples was well within the SLS standards, and they showed much lower values in all the visits. But the higher EC values were recorded in Ferro cement tanks due to dissolving cement materials. The EC value of the samples collected from asbestos roof RWH systems is higher than the tiled roof RWH systems. It can be seen that the turbidity value of all the samples in two visits is within the SLS standard. But higher turbidity values were obtained in Ferro cement tanks due to dissolving cement material.

The alkalinity of the harvested rainwater is much lower with respect to the SLS standards. There is a significant difference between the visits, as it can be seen that much lower values were obtained for alkalinity in the first visit to the Ferro cement RWH tank system.

The hardness of the harvested rainwater is much lower with respect to the SLS standards. And there is a significant difference between the visits, as it can be seen that the higher values were obtained for hardness in the second visit due to the new rainwater containing hardness. In two visits, the anions such as Fluoride, Chloride, Nitrate and Sulphate results were also within the SLS standard level.

Biological quality was much worse in some systems than the E. coli, and total coliform results did not comply with the SLS standards. This is due to the animal feces. Since the consumers use rainwater without any proper treatment it may be risk for their health condition.

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