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Operational Paper
Comparative study of rainwater quality in urban Zambia

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ABSTRACT

Five rainwater harvesting systems were installed in two peri-urban areas of Lusaka, the capital city of Zambia, consisting of six ferrocement tanks. Water samples were collected from the direct rain, roof and tank. In order to compare the rainwater quality with water from other sources, samples were also collected from piped water, boreholes and shallow wells. Rainwater was of higher quality than catchment and storage rainwater. However, harvested rainwater in tanks showed the best bacteriological quality probably due to the elimination of contamination by the first flush. The pH in the storage water was higher than that in rainwater and catchment water due to the reaction with the ferrocement tank. However, it was expected that as the ferrocement tanks matured, pH would drop in the storage water and probably meet the World Health Organisation (WHO) guidelines.

Key words | rainwater harvesting, water quality

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INTRODUCTION

According to the 2000 National Census, out of a total of 1,884,741 households in Zambia, 49.1% have access to safe water. For the urban areas, 86.1% of 3,347,069 people (652,440 households) are supplied with safe water.

Lusaka City, the capital of Zambia, is located in the south central part of the country at an elevation between 1,200 and 1,300 m above mean sea level. Lusaka is the largest city in the country covering an area of 360 km^2 and has a population of 1,056,563 out of a country total of 9,337,425 (Central Statistical Office 2002). Population growth rate in Lusaka is the third highest in the country at 2.9% per annum. More than half of the city population lives in peri-urban settlements, which lack piped water and sanitation services.

Safe water is supplied to 96% of the city population (Central Statistical Office 2002). Although this percentage is high, the supply is not on a 24-hour basis. Lusaka Water and Sewerage Company (LWSC) provided water supply services to 34% of the population in 2002. The majority of the consumers are served through private water vendors, non-governmental organisation (NGO) projects or unsafe water sources. Lusaka should have a service coverage of at least 80% (National Water Supply and Sanitation Council 2003).

Rainwater harvesting (RWH) is a technology that is traditional in some parts of Zambia. It is done on an ad hoc, very low-tech basis. However, very few RWH systems have been installed. These systems are mainly in schools in rural areas and are not widespread. Laboratory analysis of water samples from one such system showed that the water was suitable for drinking purposes.

A socio-cultural survey revealed that over 85% of the respondents to the questionnaire had harvested and utilised rainwater on an ad hoc basis. All the respondents expressed interest in harvesting rainwater using proper systems but expressed concern about the taste and debris in the rainwater they had collected (Handia *et al*. 2003).

Objective

The general objective of the research was to investigate the applicability of RWH in urban Zambia. One of the specific objectives of the research was to evaluate the quality of collected rainwater.

METHODOLOGY

Two areas with critical water shortages, Chazanga and Linda Compounds, were selected based mainly on the good quality of buildings, which would ease the fixing of gutters. The population in the selected communities was estimated at 29,000 and 18,000 in Chazanga and Linda, respectively. The community obtained its water from shallow hand-dug wells, boreholes and a stream. Residents covered long distances from their homes to the water sources. Women and children were the ones involved in drawing water for all households. Men only participated in cases where they lived alone.

One school and four houses were chosen as pilot stations. Communal catchment systems, where several roofs are combined, were considered, but no suitable site was found.

Ferrocement tanks were constructed using local labour and material. In Chazanga, 14 people (6 women) constructed the systems while 10 (5 women) were engaged in Linda.

The actual system capacity may differ from the design capacity due to construction and operation divergences. A survey was carried out to determine the actual capacity so that the assessment of the system was based on true and not design capacity. The survey yielded the results presented in Table 1.

The actual capacity of the tanks was smaller than the design capacity for all pilot stations. The major reason for this was the larger wall thickness of the tank and the fact that the shuttering needed to be wider than the tank inside diameter. However, actual slopes of the gutters were adjusted to achieve the design slope of 1 cm m^{-1}. Leaks observed in two of the tanks were successfully fixed by the same local people using a cement-based compound.

User maintenance of the RWH system is essential for the system to be successful. The users were educated to carry out the maintenance and repair of the system. The maintenance procedure proposed by Schiller and Latham (1982) was used.

Observations were carried out for the purpose of evaluating the maintenance and operation of the RWH systems. The nature of observations included checking the cleanliness of tanks, whether disease vectors (especially mosquitoes), other insects, lizards and rodents had access to tanks, any risk of accidents such as children drowning and condition of the RWH system.

Samples were collected and analysed at different times during the rainy season according to standard procedure (*Standard Methods* 1998). The samples were analysed at the Environmental Engineering Laboratory of the Department of Civil and Environmental Engineering at the University of Zambia.

Seven samples of direct rainwater were taken mainly in the two pilot areas. Roof water (catchment) was sampled by collecting water from the first flush because the research team could not be present at the systems when there was a rain event. Moreover, it was also more convenient to sample from the first flush and collected rainwater quality was not expected to be affected by the PVC piping. Nine roof water samples were collected from two pilot stations covered with two different roofing materials (galvanised iron and asbestos cement sheets). A total of 30 samples of harvested rainwater were collected from the tanks. Four samples were also collected from LWSC piped water and the same number from private boreholes. Shallow wells were sampled three times.

Harvested rainwater has been used for drinking, grey water and other uses. Therefore the objective of monitoring the water quality was to see whether it could meet the high quality requirements for drinking water. Therefore, parameters which need to be analysed in the rainwater samples are those used for World Health Organisation (WHO) guidelines for drinking water: colour, turbidity, pH, sulphate, total dissolved solids, suspended solids, nitrate, chloride, lead, zinc, faecal coliform and total coliform.

Although one roof catchment was made of asbestos cement sheets, asbestos was not analysed because it is not considered as a threat to human health (www.who.int/watersanitationhealth/GDWQ/Chemicals/asbestosum.htm; Martinson, by e-mail, 2003).

RESULTS AND DISCUSSION

Operation and maintenance

All the tanks filled up at least once during the study period. In all the pilot stations the first flush was used, according

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Table 1 | Characteristics of pilot stations

	Pilot station				
	CH 1	**CH 2**	**CH 3**	**L 1**	**L 2**
Category	Domestic dwelling	Community school	Domestic dwelling	Domestic dwelling	Domestic dwelling
Owner/name	Mr Sakala	Chazanga Community School	Mr Kanona	Mr Gondwe	Mr Chileshe
Population served	4	729	4	4	5
Roof type	Galvanised iron (GI) sheets	GI sheets	GI sheets	GI sheets	Asbestos cement (AC) sheets
Roof size (m^2)	143	283	48	74	83
Gutter length (one side) (m)	14	25	8	9	10
Gutter slope (cm m –)	1	2.3	1.5	1.1	1.5
	0.3	0.6	0.9	0.2	0.2
Piping (diameter) (mm)	75	75	75	75	75
Tank height (m)	2.1	2.0 2.1	2.0	2.1	2.2
Tank diameter (m)	2.1	2.3 2.2	2.1	2.1	2.1
Tank wall thickness (cm)	6	6 6	6	6.2	6.9
Tank volume (m^3)	7.3	8.3 8.0	6.9	7.3	7.6

Note: Diameters are internal diameters; the volumes include dead storage; two values are given for the gutter slope since each building had two gutters.

to instructions, to avoid contamination of storage water by diverting the first flush water from entering the tanks. However, there were a few occasions when the research team found that the first flush had not been drained after the previous rain event. The first flush end was easy to use because it was simple due to improvising. It was also found to be effective as long as it was used. However, it needed to be cleaned before the next rainy season because of biofilm formation on the inside.

Most of the users abstracted amounts of water from the tanks that were recommended by the research team. Difficulties continued to be experienced at the school because of lack of co-operation from the staff. Pupils could go at any time and run the tap for drinking purposes or for cooling their heads when it was hot. The reason for the lack of commitment by the staff could be that they were not the direct beneficiaries.

Some gutters had their joints soldered again due to leakage. Others were shifted so that no rainwater would be lost during light and heavy rains. Some gutters at pilot stations L1 and L2 had very gentle slopes leading to ponding. Gutters that did not have a good and consistent slope were realigned to have the desired slope.

Quality of harvested rainwater and water from other sources

Rainwater

A summary of the range of laboratory results is presented in Table 2. All physicochemical parameters tested passed WHO guidelines except for one sample which exceeded the guideline value for turbidity. The failure in turbidity is attributed to dust in the atmosphere. Two out of four

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Table 2 | Quality of rainwater

	Sampling location			
Parameter	**University**	**Chazanga**	**Linda**	**WHO guideline**
pH	6.5 to 8.4	7.5	7.1	6.5 to 8.5
Total dissolved solids (mg l^{-1})	4.2 to 12	2.8	13.5	1,000
Total suspended solids (mg l^{-1})	< 2.0	< 2.0	< 2.0	*
Sulphates (mg l^{-1})	< 0.01 to 2.0	22	19.1	250
Turbidity (NTU)	0.14 to 1.64	10.3	4.95	5
Chlorides (mg l^{-1})	1.0 to 3.0	3.0	3.0	250
Nitrates (as NO_3-N mg l^{-1})	< 0.01	2.9	< 0.01	10
Lead (mg l^{-1})	< 0.01	—	—	0.01
Zinc (mg l^{-1})	< 0.001	—	—	3.0
Total coliform (no. per 100 ml)	0 to 27	—	—	0
Faecal coliform (no. per 100 ml)	0 to 1	—	—	0

— parameter was not analysed; * no WHO guideline.

samples tested for bacteriological quality did not meet the guidelines. Only one sample had one faecal coliform present. The source of bacteriological contamination was suspected to be dust and bird droppings. According to Vasudevan *et al*. (2001), *Escherichia coli* may survive in soils of tropical countries. In addition, dust from the roof surfaces introduces microorganisms into water (Ghanayem 2001). The other three samples were not analysed as the sampling apparatus was not sterilised.

Roof water

Table 3 presents a range for each water quality parameter for rainwater collected from the roof area (catchment). Three out of nine samples had lower pH values than the WHO guideline. Rainwater is naturally acidic due to carbon dioxide in the atmosphere, burning of coal and petroleum products, and industrial activity producing acid rain which can extend well beyond zones of industrial activity (Heijnen 2001). Most poor households in Lusaka use charcoal and petroleum products as sources of energy for cooking and lighting. Industries were located within 10 km from the two communities.

A sample from Linda and another from Chazanga exceeded the limits for turbidity and nitrates, respectively. Dust and debris on the roof and in the atmosphere caused the high turbidity. The high nitrate level was attributed to pollution emanating from bird droppings and insects.

Out of four samples from L2, only one had a higher lead content than the limit. The failure recorded for lead was attributed to the gutter-joint soldering material used to seal the observed leaks. The soldering rods contained lead.

Only one out of five samples from CH2 slightly exceeded the WHO limit for zinc. However, this is not a health-based but acceptance-based guideline. The high zinc content was attributed to the roof and gutter material made of galvanised sheet, which contained zinc.

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Table 3 | Quality of roof water

Parameter	Catchment type and location: Galvanised iron, Chazanga	Catchment type and location: Asbestos cement, Linda	WHO guideline
pH	5.5 to 7.9	6.5 to 7.4	6.5 to 8.5
Total dissolved solids (mg l^{-1})	2.5 to 15	36 to 43.6	1,000
Total suspended solids (mg l^{-1})	<2.0	<2.0	*
Sulphates (mg l^{-1})	<0.01 to 2.0	<0.01 to 7.6	250
Turbidity (NTU)	0.20 to 2.81	0.45 to 13.2	5
Chlorides (mg l^{-1})	0 to 5.0	0 to 9.0	250
Nitrates (as NO_3-N mg l^{-1})	<0.01 to 26.0	<0.01 to 1.32	10
Lead (mg l^{-1})	<0.001 to 0.01	<0.001 to 0.27	0.01
Zinc (mg l^{-1})	0.14 to 3.16	<0.001 to 0.025	3.0
Iron (mg l^{-1})	<0.01	—	0.3
Total coliform (> per 100 ml)	30 to TNTC	33 to TNTC	0
Faecal coliform (> per 100 ml)	16 to TNTC	6 to TNTC	0

— parameter was not analysed; * no WHO guideline; TNTC, too numerous to count.

Moreover, this location had the largest roof area and gutter length.

All samples failed to meet WHO guidelines in terms of total and faecal coliforms. This was expected as this water was sampled from the first flush which diverts contaminated water from entering the tank. Therefore the results obtained were discarded.

Storage water

Results of harvested rainwater stored in the tanks, presented in Table 4, showed that the water quality, as indicated by the measured parameters, fell within WHO guideline limits except for pH, lead and coliforms. Fifty-seven per cent of the samples had pH values above the limits. One sample had a pH value lower than the limit. However, the pH level showed a trend of reducing as the rainy season progressed. Only pilot station CH3 always had pH values above the WHO range because sampling stopped a month before the last samples were collected from the other stations and a cement-based compound was used to seal a serious leak in the tank. Low pH at L1 was attributed to acid rain, which was discussed in the preceding section.

Also, 17% of the samples failed to meet the lead limits because of the gutter-joint soldering material which contained lead. The soldering material left in the gutters, by the people who had been sealing the leaks, could have caused the high value of 14 mg l^{-1} at CH1. Another potential source of lead, though insignificant, could be the deposition of lead particles on the roof and gutters from industrial and traffic pollution (Gould 2001). Most of the petrol used in Zambia is leaded.

Table 4 | Quality of storage rainwater

	Pilot station and type of roof					
Parameter	**CH 1 (GI roof)**	**CH 2 (GI roof)**	**CH 3 (GI roof)**	**L 1 (GI roof)**	**L 2 (AC roof)**	**WHO guideline**
pH	7.3 to 9.9	6.5 to 9.2	9.2 to 9.4	6.1 to 9.0	6.6 to 10.2	6.5 to 8.5
Total dissolved solids (mg l^{-1})	24 to 60	8.5 to 102	14.5 to 74	6.5 to 50	20 to 45.4	1,000
Total suspended solids (mg l^{-1})	< 2.0	<2.0	<2.0	<2.0	<2.0	*
Sulphates (mg l^{-1})	<0.01 to 78	<0.01 to 30	1.0 to 56	<0.01 to 74	<0.01 to 6.4	250
Turbidity (NTU)	0.60 to 3.46	0.20 to 3.40	0.65 to 2.11	0.20 to 3.9	0.27 to 1.12	5
Chlorides (mg l^{-1})	0 to 7.0	0 to 15	0 to 11	0 to 17	0 to 4.0	250
Nitrates (as NO_3-N mg l^{-1})	<0.01 to 7.90	<0.01 to 4.50	<0.01 to 8.79	<0.01 to 8.7	<0.01 to 2.40	10
Lead (mg l^{-1})	<0.001 to 14	<0.001 to 0.65	<0.001 to 0.01	<0.001 to 1.12	<0.001 to 0.02	0.01
Zinc (mg l^{-1})	<0.001 to 0.77	0.002 to 0.961	<0.001 to 0.72	<0.001 to 0.46	<0.001 to 0.040	3.0
Fluorides (mg l^{-1})	—	0.16	—	—	—	1.5
Total hardness (as $CaCO_3$ mg l^{-1})	—	20	—	—	—	500
Total coliform (no. per 100 ml)	0 to 21	0 to 30	0	0	0 to 6	0
Faecal coliform (no. per 100 ml)	0 to 5	0 to 6	0	0	0 to 4	0

— parameter was not analysed; * no WHO guideline.

About 18% and 14% of the samples failed in total coliforms and faecal coliforms, respectively. Again the reason for this could be bird dropping, insects and dust. Presence of cockroaches, mosquito larvae and insects in all the tanks except at L1 could also have contributed to the bacteriological contamination. Dust could have had more influence in contaminating the water at CH1 than any other location as it was situated along a busy gravel road. Although there was a first flush, dust could still be carried into the tank by roof water if the first flush was not emptied before the next rain event. Three out of six samples taken at this location failed in bacteriological quality. After the tank at L1 was drained and cleaned, no further contamination was recorded. The school was the other place that exhibited contamination. Siphoning of water from the tanks by the pupils when the taps were not running because of low water level in the tanks could have been another source of contamination at the school apart from bird droppings. Two pilot stations never recorded any contamination.

Piped Lusaka water and sewerage company water

The water was characterised by moderate hardness as shown in Table 5. Total hardness ranged between 112 and 184 mg l^{-1} as $CaCO_3$. Two of the four samples had lower pH than the guideline values. Values of pH 6.0 and 6.1 were recorded. One sample had turbidity higher than the limit. A value of 16.9 NTU was measured.

Two different samples recorded both faecal and total coliforms. These two samples were collected in the rainy season and from an area where supply was shut at night.

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Table 5 | Quality of water from other sources

Parameter	Piped LWSC	Private boreholes	Shallow wells	WHO guideline
pH	6.0 to 7.5	6.3 to 7.9	6.1 to 7.5	6.5 to 8.5
Total dissolved solids (mg l^{-1})	85.2 to 115	273 to 462	203 to 757	1,000
Total suspended solids (mg l^{-1})	<2.0	—	—	*
Sulphates (mg l^{-1})	<0.01 to 51.0	9.3 to 63	20 to 47.1	250
Turbidity (NTU)	0.5 to 16.90	0.26 to 4.19	0.751 to 35.4	5
Chlorides (mg l^{-1})	3.9 to 12.0	10 to 18.0	10 to 29.0	250
Nitrates (as NO_3-N mg l^{-1})	<0.01 to 2.4	0.64 to 7.90	0.56 to 6.8	10
Lead (mg l^{-1})	—	<0.001	—	0.01
Zinc (mg l^{-1})	—	<0.001	—	3.0
Iron (mg l^{-1})	<0.01	<0.01	0.09 to 1.74	0.3
Manganese (mg l^{-1})	<0.01 to 2.16	<0.01 to 0.64	<0.01	0.3
Total phosphates (mg l^{-1})	<0.01 to 2.3	0.37 to 8.78	3.35 to 8.79	*
Ammonium (as NH_4-N mg l^{-1})	0.06 to 44.8	<0.01 to 0.08	<0.01 to 0.78	1.5
Calcium (mg l^{-1})	3.84 to 49.6	97.6 to 105.6	3.2 to 102.4	200
Magnesium (mg l^{-1})	3.84 to 128	23.04 to 56.64	0.96 to 65.3	200
Fluorides (mg l^{-1})	0.12 to 0.32	0.25 to 4.78	0.3 to 4.70	1.5
Total hardness (as $CaCO_3$ mg l^{-1})	112 to 184	340 to 500	27.6 to 528	500
Total coliform (no. per 100 ml)	0 to 120	41 to TNTC	9 to 37	0
Faecal coliform (> per 100 ml)	0 to 50	0 to 56	0 to 2	0

— parameter was not analysed; * no WHO guideline.

The possible cause of contamination could be infiltration of polluted water (from leaking sewers and stormwater) when pipes were not under pressure. The poor quality water supplied by the water utility should be a concern to the water company as consumers at times drink the water without disinfecting it.

One sample exceeded the manganese and ammonium guideline values.

Private borehole water

Results of the analysis of water sampled from private boreholes are presented in Table 5. The results were characterised by very hard water with high values of total dissolved solids. Only one of the four samples had higher pH and manganese values than the WHO limits. Three of the samples exceeded the limits for fluorides. None of the samples met the WHO guideline with respect to total coliforms while two contained faecal coliforms.

Shallow wells (alternative sources)

Of the three samples tested, all samples had high values of total coliforms, in some cases too numerous to count (TNTC) as shown in Table 5. Only one sample did not contain any faecal coliforms. Two samples failed in terms of turbidity. One of the samples exceeded the fluorides guideline value. The water was very hard to extremely hard with one sample value above the limit. This meant that users of this water for washing purposes had to use more washing detergent than those who used rainwater.

Comparison of rainwater with water from other sources

Rainwater (both direct and harvested) was of higher quality than water from other sources according to Tables 2 to 6. Rainwater was also very soft and had the lowest hardness compared with the other sources. This meant users needed less soap when washing.

A scoring system was formulated so that the quality of different water could be compared systematically. Water that satisfied the WHO guideline for a given parameter was assigned a value of 5, which means that the water was of high quality for that parameter. When all samples failed to meet the guideline, the water was assigned a value of 0 for the parameter. Results falling between the two extremes were given values according to Table 6. For example, if the percentage of samples satisfying the WHO guideline fell between 50% and 75% for a given parameter, the water scored a value of 3. In addition, individual values were also considered in making further comparisons.

Results of using this scoring system presented in Table 6 show that rainwater had a higher quality than roof and storage rainwater. However, storage rainwater in tanks showed better bacteriological quality than rainwater probably due to the elimination of contamination by the first flush. Although the results for the bacteriological quality of roofwater were discarded, it was expected that its quality would not be better than for rain and storage water. The pH in the storage water was higher than that in rainwater and catchment water due to the reaction with the ferrocement tank. However, it was expected that as the ferrocement tanks matured, pH would drop in the storage water to comparable values and probably meet the WHO guidelines.

LWSC water had better quality than water from private boreholes and shallow wells (alternative sources). However, shallow well water was better in terms of pH than the other two sources, while private borehole water was superior with respect to turbidity.

Water from shallow wells and private boreholes exhibited a similar range of values for most measured parameters. The former had better quality in terms of fluorides and manganese, but was worse in bacteriological quality and showed faecal contamination. This could be due to the high water table in the rainy season resulting in flow from pit latrines to the shallow wells (Handia 2001).

Effect of some variables on quality of harvested rainwater

The effect of some variables on the quality of the harvested rainwater was also analysed. It was observed that rainfall pattern (for continuous rain events) and rainwater quality (when it is good quality) had a high positive effect on the harvested rainwater quality. Proper maintenance and operation of first flush also had the same effect.

Roof catchment type had no effect on water quality except for zinc when galvanised iron and asbestos roofing sheets were considered. The zinc values recorded from roofs made from galvanised iron sheets were much higher than those from the asbestos cement roofs. The gutter material used also contributed to the zinc content.

It was not possible to draw conclusions on effect of storage period on the quality of harvested rainwater due to the short period of rainwater storage of 3 months since there was an inflow for each rain event. However, it was observed that storage period had a considerable positive effect on the storage water.

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Table 6 | Rainwater quality versus quality of water from other sources

	Harvested rainwater quality			Quality of water from other sources		
Parameter	**Rainwater**	**Catchment water**	**Storage water**	**Piped LWSC**	**Private boreholes**	**Shallow wells**
pH	5	3	2	3	4	5
Total dissolved solids (mg l^{-1})	5	5	5	5	5	5
Total suspended solids (mg l^{-1})	5	5	5	5	5	5
Sulphates (mg l^{-1})	5	5	5	5	—	—
Turbidity (NTU)	4	4	5	4	5	2
Chlorides (mg l^{-1})	5	5	5	5	5	5
Nitrates (as NO_3-N mg l^{-1})	5	4	5	5	5	5
Lead (mg l^{-1})	5	4	4	—	5	—
Zinc (mg l^{-1})	5	4	5	—	5	—
Iron (mg l^{-1})	—	—	—	5	5	5
Manganese (mg l^{-1})	—	—	—	4	4	5
Total phosphates (mg l^{-1})	—	—	—	5	4	3
Ammonium (as NH_4-N mg l^{-1})	—	—	—	2	5	5
Calcium (mg l^{-1})	—	—	—	5	5	5
Magnesium (mg l^{-1})	—	—	—	5	5	5
Fluoride (mg l^{-1})	—	—	5	5	2	2
Total hardness (as $CaCO_3$ mg l^{-1})	—	—	5	5	5	3
Total coliform (no. per 100 ml)	3	—	3	3	1	1
Faecal coliform (no. per 100 ml)	3	—	4	3	1	2

— parameter was not analysed

Scoring system

Samples meeting WHO guideline (%)	Point	Water quality
100	5	Very high
75 to <100	4	High
50 to <75	3	Medium
25 to <50	2	Low
0 to <25	1	Bad

CONCLUSIONS

Direct rainwater met the WHO guidelines for drinking water except for bacteriological quality. The contamination was attributed to bird droppings. About 10% of the roof water failed to meet the lead and zinc limits. The gutter-joint soldering material may have caused the high lead content. High zinc concentration in the roof water was attributed to the galvanised iron sheets used for roofing and rain guttering. Storage rainwater in tanks had pH values above the limit due to the influence of the ferrocement tanks. However, this was expected to drop as the tanks matured. Bacteriological contamination was also evident in the storage rainwater as 18% and 14% of the samples failed to meet the limits for total and faecal coliforms, respectively.

Direct rainwater was of better quality than roof and storage water. However, the simple first flush was effective in eliminating bacteriological contamination as storage rainwater was superior in terms of this parameter than direct rainwater and roof water. Rainwater was of higher quality than water supplied by a water utility, borehole and shallow well water.

Continuous rain events, high quality direct rainwater, and proper maintenance and operation of the RWH systems had a positive effect on the quality of harvested rainwater. Galvanised iron and asbestos cement roofing sheets did not show any influence on the quality of harvested rainwater except for zinc. Samples from the galvanised iron roof had higher zinc content than those from asbestos cement due to the zinc content in the galvanised iron sheets.

It was therefore possible to harvest rainwater that could meet the WHO guidelines as long as materials used to construct RWH systems were carefully selected to avoid contamination of the rainwater. Simple disinfection methods such as boiling and chlorination are recommended if water is to be used for drinking purposes.

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