HEALTH BURDEN OF THE CONSUMPTION OF ROOFTOP RAINWATER HARVESTING SYSTEMS IN BUEA SUB–DIVISION, CAMEROON

ABSTRACT

Roof harvested rainwater is generally considered to be safe and is mostly used without prior treatment. However, the population is exposed to several health risks associated with contaminated pathogens found in harvested rainwater. This study assessed the health risks of the currently practiced rooftop rainwater harvesting partially used for drinking water supply. Multi-stage sampling was employed to evaluate the microbial properties of 20 rainwater cistern across four communities (Bonakanda, Bova I and II, and Ewonda) in BueaSub-division. A total of 358 households were randomly sampled for rainwater harvesting potentials and a semi-quantitative risk assessment matrix was used to estimate potential health risks of untreated harvested roof rainwater for drinking purpose. Rainwater is a principal cost-effective alternative to other sources of water supply for households. While its uses for other purposes such as cleaning and irrigation present limited risks to the population, its sparing use for drinking without any treatment was observed to results in health risks. The study thus recommends pre-treatment of harvested rainwater through filtration, chlorination, ultraviolet disinfection, and or boiling, for potable purposes.

1. INTRODUCTION

Rainwater harvesting is a technique that communities around the world had used ancient times and has significantly evolved over the years (Cowie, 2018; Renewable Energy Hub, 2018; Rochat, 2019; Battenberg, 2009). Safe and readily available water is important for public health, whether it is used for drinking, domestic use, food production or recreational purpose (Namrata & Han, 2006; Hattum & Worm, 2006). Improved water supply and sanitation, and better management of water resources, can boost countries' economic growth and can contribute greatly to poverty reduction (Singh, 2017).

In 2010, the UN General Assembly explicitly recognized the human right to water and sanitation. Everyone has the right to sufficient, continuous, safe, acceptable, physically accessible, and affordable water for personal and domestic use. Sustainable Development Goal target 6.1 calls for universal and equitable access to safe and affordable drinking water (UN 2019).The target is tracked with the indicator of "safely managed drinking water services" – drinking water from an improved water source that is located on premises, available when needed, and free from fecal and priority chemical contamination (WHO, 2019).Clean water is an essential element for human health, wellbeing and prosperity. Whether used fordrinking, cleaning, food production or industrial output, access to sufficient water resources is a basic human need. Access to sufficient and safe sanitation facilities is also vital for hygiene, disease prevention, and human health. The World Health Organization highlights the contribution of poor water and sanitation access to health, mortality and reduced poverty alleviation (Ritchie & Roser, 2019).

According to Kim *et al.* (2005), rainwater harvesting may be one of the best methods available to recovering the natural hydrologic cycle and enabling urban development to become sustainable.

The harvesting of rainwater has the potential to assist in alleviating pressures on current water supplies and storm water drainage systems. Rainwater collection has the potential to impact many people in the world (Julius *et al.*, 2013).Although harvested rainwater is mostly used for non-drinking purposes, in some circumstance’s rainwater can be treated to be safe for human consumption. The United Nations Environment Program (UNEP) (2009) highlighted the growing popularity of rainwater collection techniques, and recognized its potential to reduce the number of people who do not have access to water for human consumption(Gur, & Spuhler, 2019; Cowie, 2018; Hattum & Worm, 2006). Known as Rooftop Rainwater Harvesting (RRWH), or simply rainwater harvesting, this water optimization process has been widely implemented in rural areas in countries like Brazil, Kenya, China, New Zealand and Thailand (Cleanawater, 2015; Al-Batsh, Al-Khatib, Ghannam, Anayah, Jodeh, Hanbali, & Valk, 2019).

Contaminated water and poor sanitation are linked to transmission of diseases such as cholera, diarrhea, dysentery, hepatitis A, typhoid, and polio (Schets, Italiaander & Berg, 2010; Hill, 2019). Absent, inadequate, or inappropriately managed water and sanitation services expose individuals to preventable health risks. This is particularly the case in health care facilities where both patients and staff are placed at additional risk of infection and disease when water, sanitation, and hygiene services are lacking. Globally, 15% of patients develop an infection during a hospital stay, with the proportion much greater in low-income countries (WHO, 2019).Some 829 000 people are estimated to die each year from diarrhea as a result of unsafe drinking-water, sanitation, and hand hygiene. Yet diarrhea is largely preventable, and the deaths of 297 000 children aged under 5 years could be avoided each year if these risk factors were addressed. Diarrhea is the most widely known disease linked to contaminated food and water but there are other hazards. In 2017, over 220 million people required preventative treatment for schistosomiasis – an acute and chronic disease caused by parasitic worms contracted through exposure to infested water (WHO, 2019).

Water is essential for life and good health. Fresh water is not only needed for drinking but also cooking, food production and a variety of other uses such as sanitation, hygiene and cleanliness practices. Lack of sanitation can force people to defecate in the open, in rivers and near areas where children play. These habits result in 115 deaths every hour in the African Region. Bacteria, viruses, parasites and pollution contaminate freshwater stores resulting in water scarcity. Water scarcity is a major problem even in areas where there is plenty of rainfall. A lack of clean water increases the risk of diarrheal diseases as cholera, typhoid fever and dysentery, and other water-borne tropical diseases. Water scarcity can also lead to diseases such as trachoma (an eye infection that can lead to blindness), plague and typhus (WHO, 2015).

Though abundantly endowed with rainfall critical in recharging surface and ground water sources, water scarcity though demographic growth and inadequate water management have resulted in growing water scarcity supplied by the national water corporation and community water schemes(Sayana, Arunbabu, Kumar, Ravichandran & Karunakaran, 2010). This is contrary to other regions where rain water harvesting is a veritable alternative during arid periods in drier climates (Zavala, Prieto & Rojas, 2018).Rooftop rainwater harvested has therefore one of the key sources of adaption by the population. Rainwater harvesting system is not a replacement of all other water supply systems but a sustainable addition to the other water supply systems to augment water supply Buea, Cameroon. This comes at a time where access to potable water has been highly compromised due population growth overwhelming the available water supplies and infrastructure, thus undermining the human rights of the population to safe drinking water (Suh, 2016). However, there are growing health concerns of the use of this water given that it is not in all cases where its safety measures are respected. This study therefore evaluates the health risks associated with consumption of harvested roof rainwater.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out on the eastern slopes of Mt. Cameroon in Buea Subdivision of the Fako Division of the South West Region of Cameroon. Buea is located between Latitude 4° 09' 10" N and Longitude 9° 14' 28" E. (Figure 1) and had a population of about 90,088 inhabitants (according to the 2005 population census by National Institute of Statistics, Cameroon).

The topography is hilly and characterized by numerous springs and streams (Mbua, 2013). The most conspicuous physical feature of Buea is Mount (Mt) Cameroon which is the highest mountain in west and central Africa with a height of about 4095m above sea level (Mbua, 2013). Climatically, air masses (warm moisture laden winds mainly the Monsoon of western Sub-Saharan Africa) carrying rain forming clouds blowing in from the coast are blocked by the mountain forcing the air to rise, then cools down and condenses resulting in precipitation. This occurs from April till late October and accounts for the rainy season. The dry season from early November till early late April is brought about by North-East Trade Winds. The Mt Cameroon region has the highest precipitation in the entire nation. Debundscha (with about 10000 mm/a) which is amongst the five rainiest places in the world is located on the southwestern slope of the mountain. Buea on the eastern slopes also has high annual precipitation of between 3000 to 5000 mm. This high precipitation recharges the aquifers and guarantees a sustainable groundwater resource for the region. The precipitation percolates through the porous scoriaceous materials into the perched water table recharging the aquifer. Also, the jointed nature of some of the basaltic rocks and the porous nature of the scoriaceous materials make this area rich hydrological reservoir (Lambi & Kometa, 2009).

2.2 Methodology

2.2.1 Data Collection

Desk Study (Secondary Data Sources)

The study reviewed related literature on the characteristics and bacteriological impacts of rainwater harvesting systems and a general topographic mapping system was employed for delimitation of the study area. This involved consultation of a base map of the area, to further delineate the sample points.

Reconnaissance Survey

A pre-field survey was conducted in the month of March 2019. This survey introduced the research study, its relevance and time frame to local authorities as well as inhabitants of the selected communities, followed by a verbal approval which further granted authority assistance whenever and wherever needed. Visits were paid to several heads of households to get quality information on the status quo.

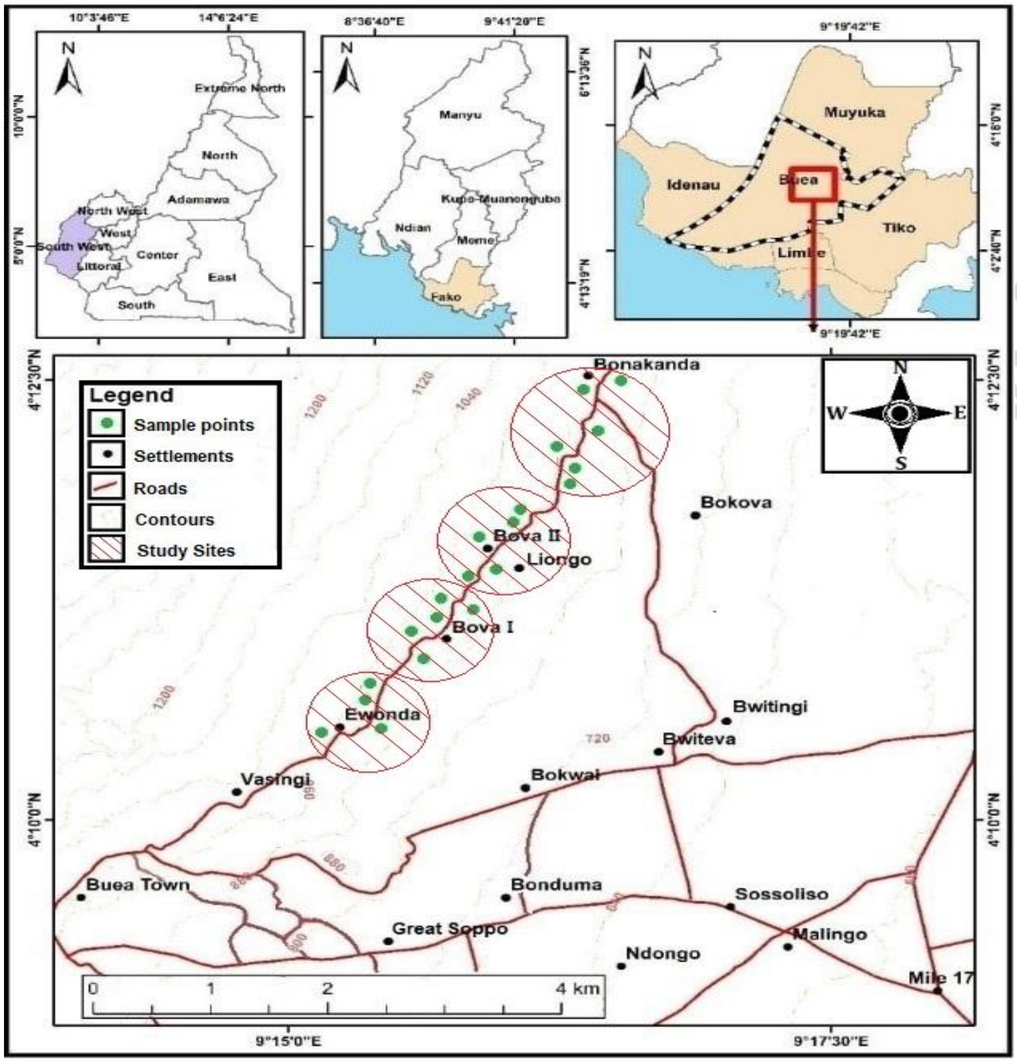

Figure 1: Location of sample sites and sample points in topographic map of Buea in Cameroon

Field Work (Primary Data Sources)

This study was conducted in the months of April and July for comparative analysis and involved sample collection and administering of questionnaires to inhabitants in order to obtain their water to health perception.

Sampling Strategies

Generally, scientific research involves two major sampling strategies. Probability and non-probability sampling methods. However, this study employed the purposive (homogeneous) sampling technique that is drawn from a non-probability sample category which involves selection based on characteristics of a population and the objective of the study.

Sample Size Determination

The corrected sample size was estimated using the Taro Yamane's (1967) Formula:

$$n = \frac{N}{1 + N(e)^2}$$

Where:
n = Corrected Sample Size
N = Estimated population size = 3410 Inhabitants
e = Margin of error (*MoE*) = 5% or 0.05
Confidence level (CL) = 95%
Thus:
$n = N/ [1+N (e)^2]$
$n = 3410/ [1+3410 (0.05)^2]$
$n = 3410/ 9.53$
n = 358

Sampling Method, Inclusion and Exclusion Criteria

Questionnaire forms were tailored to achieve resourceful information with regards to the objectives of the study. These forms comprised of formal standardized semi-structured closed-ended and open-ended questions which sought quantitative information about the water consumption pattern of a typical household, administered by the research team. Thereafter, data obtained by means of questionnaire was further analyzed with the aid of Microsoft Office Excel 2016 statistical package. The closed-ended questions enabled respondents to choose from a list of answers, whereas, open-ended questions required respondents to express their opinion independent of any influence from the part of the researcher.

A total of 358 questionnaires were administered in 4 villages in the Buea sub-division, which Included; Bonakanda, Bova I, Bova II, and Ewonda. All questionnaires distributed were obtained giving a total response rate of 100%. This high response rate is justifiable because the questionnaires were administered onsite at the residences of the respondents by a dual team of facilitators who exercised patience for further scrutiny by respondents at their own pace. This procedure was followed for both literate and illiterate respondents to avoid alteration of information required and that which was provided.

The questionnaire form was further fragmented into sections. Section (A) targeted socio-demographic information of Respondents (demography and literacy level). Section (B) focused on water source consumption data. Section (C) concentrated on detail information of the domestic water demand and consumption pattern of respondents. The goal of section (C) was to assess respondent's knowledge on the health risks associated with consumption of pre-treated roof harvested rainwater. Rainwater water quality was determine following the procedures described in Oxoid's (2019) study.

2.2.2 Data Analysis

Both primary and secondary data were used in the study. Primary (Quantitative) data was obtained through experiments and surveys and were analyzed scrupulously by a research team of porters, facilitators, moderators, a statistician and a laboratory technician. A topographic map of Buea was constructed using "ESRI ARCGIS 10.2.2" map design package. Data from laboratory experiments and questionnaire survey were analyzed through of Microsoft Office Excel 2016. Secondary data (data not collected by the researcher) from literature review were also used in the study. The data obtained were represented in the forms of tables, figures, graphs, bar charts and text. Results of data analysis are presented sequentially accompanied by discussion to facilitate coherency and understanding.

3. RESULTS

3.1 Socio – Demographic Characteristics of Respondents

Table 1 illustrates the age group of respondents, wherein the dominant age group ranged from 53 years and above, amounting to 29.3% of the sample population as against 17.0% who are either 30 years old or below. This disparity was based on natural selection criterion wherein most households' heads qualify for participation by their age.Also, the sample population is characterized by a youthful population structure (table 2) dominated by children (48.2%) followed by adults and the old, that is, 37.5% and 14.4% respectively. Again, this youthful population structure is dominated by the female sex group (69.1%) as against the male sex group (30.9%).

Table 1: Socio – Demographic Characteristics of Respondents

Indicator	Category	Frequency	Percentage
Age Group	≤ 30	61	17.0
	31 – 41	99	27.7
	42 – 52	105	26.0
	≥ 53	93	29.3
Population Structure	Children	315	48.2
	Adults	245	37.5
	Old	94	14.4
Gender	Male	202	30.9
	Female	452	69.1
Educational Level	No formal education	147	41.1
	Elementary School	112	31.3
	High School	78	21.8
	Higher Education (University)	21	5.9

The socio-demographic data obtained included; the age group, population structure, gender and level of education of participants as illustrated in table 3 above.As observed in Table 1, 72.4% of respondents are illiterate or have attained elementary education, whereas the remainder 21.8% and 5.9% attained high school and university level respectively.

3.2 Health Risk of Bacteriological Contamination

A model risk assessment matrix (Table 2) was developed for the purpose of this study. From the analysis below, 5 major RRWH components were used to assess the sanitary conditions of 20 RRWH sites. The sanitary level of each component was scored on a range from 1 – 3 (Table 2). The overall sanitary conditions of various RRWH components were employed as partial indicators for water quality contamination risks assessment (health burden). Each component was first assessed using the presence/absence test (to identify the availability of the components), thereafter, each available component was allocated a sanitary score which was later represented as percentages for each case.

Table 2: Probable Point of Contamination Based on Sanitary Conditions of RRWHS

Sample Site	Probable Point of Contamination					
	No Contamination	Catchment Area	Conveying System	Filtration System	Storage System	Point of Use
BS01	√					
BS02	√					
BS03					√	
BS04		√				
BS05	√					
BS06		√				
BS07					√	
BS08					√	
BS09					√	
BS10			√			
BS11					√	
BS12		√				
BS13	√					
BS14		√				
BS15	√					
BS16					√	
BS17	√					
BS18		√				
BS19					√	
BS20					√	
Total	**6**	**5**	**1**	**0**	**8**	**0**
%	**30**	**25**	**5**	**0**	**40**	**0**

Table 2shows the percentage characterization of various samples based on probable point of contamination. With 30% of the samples indicating no source of microbial contamination, 25% indicating probable microbial from catchment areas, 5% from the conveying systems, 0% from both filtration systems and point of use, and 40% from storage systems.

As observed (Table 3), a total of 358 households were sampled for further assessment of the correlation of the likelihood of disease outbreaks and the severity of the impacts. From the analysis, 71.2% of respondents were aware of the possibility of diseases to arise from the consumption of contaminated rainwater against 28.8% who were neutral or unaware. More than ninety-one per cent of the respondents consumed rainwater without any form of treatment against 8.4% who practiced treatment of some form though inadequate. No household (0%) practiced adequate treatment of rainwater before consumption.

Table 3: Health Burden Based on Respondents Perceptions

Indicator	Category	Frequency	Percentage

Awareness of health hazards associated to contaminated rainwater	Yes	255	71.2
	No	103	28.8
Practice on rainwater treatment of any form	No Treatment	328	91.6
	Inadequate Treatment	30	8.4
	Adequate Treatment	0	0.0
Health issues associated with the use of contaminated rainwater	Typhoid Fever	112	31.3
	Diarrhea	90	25.1
	Others	75	20.9
	No Infection	81	22.6
Household members likely affected by rainwater	Children	157	43.9
	Adults	92	25.7
	Old	108	30.4
Severity of affected persons	Admitted Cases	117	32.7
	None – Admitted Case	241	67.3

From the total, 31.3% of respondents indicated cases of typhoid fever in the household against 25.1% for diarrhea cases and 20.9% associated to other forms of waterborne diseases such as fungal infection, itching of the skin, skin rash amongst others. A majority of household members (43.9%) affected by waterborne diseases associated to rainwater consumption were children. The rest were adults and the old with 25.7% and 30.4% respectively. The number of admitted (hospitalized) cases associated to diseases caused by consumption of microbial contaminated rainwater was 32.7% against 67.3% for none – hospitalized cases.

3.3 Health Burden Based on Sanitary inspection

Sanitary inspection is a powerful and generally applicable tool for the risk assessment of water supply systems. It is widely used in small water supply settings to support the identification and management of high-priority risk factors. Sanitary inspections can also support water safety plan (WSP) implementation, including the identification of hazardous events and potential control measures. Results of sanitary inspections can inform more systematic risk assessments that may be conducted within a WSP (such as the risk matrix), (WHO, 2016).

A total of 11 parameters were employed in the study to evaluate the quality of the harvesting system in order to estimate the health risks associated in the consumption of harvested rainwater. This analysis was based on several rainwater harvesting system components as well as the impacts of other external factors. The availability and effectiveness of each component or factor was tested so as to obtain either a positive or negative outcome per each parameter, from which a conclusion was made based on the likelihood of a potential health hazard derived from possible points of contamination represented as percentage risk frequency for each parameter.

From the analyses in Table 4, the minimum sanitary risk frequency for a likely microbial contamination and disease outbreak was 20% from the total of 20 RRWH sites against a maximum of 100%. The above analysis illustrates a high-risk trend which could be associated to the poor sanitary conditions since a majority of the RRWH sites have risk levels above the margin of 50%.

Table 4: Risk factors occurring in RRWH, identified by sanitary inspection in the Mount Cameroon Region, Buea.

	Sanitary risk inspection parameters	No	Yes	Risk frequency (%)
	Roof Rainwater Harvesting: 20 RRWH sites inspected			
1	Catchment area	6	14	**70**
2	Debris screen	0	20	**100**
3	Conveying system	12	8	**40**
4	First-flush diversion system	1	19	**95**
5	Filtration system	1	19	**95**
6	Cistern lead	5	15	**75**
7	Contamination from external water source	16	4	**20**
8	Animals access within 10m of the system	7	13	**65**
9	Nature of the tap or point of use	5	15	**75**
10	Contamination from a latrine within 10m of the system	15	5	**25**
11	Pollution from other sources within the system	16	4	**20**

The checklists also provide a simple quantitative classification of the level of safety of the water supply system (including very high risk, high risk, medium risk and low risk), by counting the number of YES answers. Such a risk scoring system is particularly useful when sanitary inspection forms are used more broadly – for example, as part of a surveillance program. It can help to determine the status of small water supply systems and inform regional and national priorities. For instance, results can shed light on which systems are the "riskiest" (for instance, based on supply type or location) and which risk factors fail the most frequently (Table 5).

A semi-quantitative risk assessment matrix (Table 5) was used to estimate the probability of health hazard to arise from the consumption of rainwater containing strands of *E. coli* and *Salmonella spp*. From 20 rainwater sample sites, assessments were made based on; the concentration of coliform organisms per rainwater samples using the Most Probable Number (MPN). The coliform concentrations of various samples were fragmented in subcategories and associated with several risk codes. Also, the status (presence or absence) of fecal coliforms (*E. coli*, *Salmonella Spp*.) within each sample was employed in the isolation of samples in the matrix. As illustrated, 30% (6 rainwater samples; BS01, BS02, BS05, BS13, BS15, BS17) indicated no coliform a low risk of microbial contamination, hence, are 0.01% likely to exert health burden and thus are safe for drinking purposes. 15% (BS06, BS16, BS19) and 15% (BS04, BS11, BS12) of rainwater samples indicated coliform concentrations within the moderate and high contamination risks zones respectively. Samples with the moderate and high risks zones have a 1% to 100% likelihood of causing diseases (exert a health burden) on the population thus may require medical attention of some degree. The remainder 40% (BS03, BS07, BS08, BS09, BS10, BS14, BS18, BS20) lie within the critical contamination risk zone with a 100% likelihood to cause diseases. Samples within the critical risks zone may require immediate medical attention.

Table 5: Probability Assessment of Health Burden (Semiquantitative Risks Matrix)

	Severity or Consequences				
	Insignificant or no impact (1)	**Minor compliance impact (2)**	**Moderate aesthetic (3)**	**Major regulator impact**	**Catastrophic public health impact (5)**

					(4)	
Likelihood or Frequency	**Almost (5)** Once a day.	5	10	15	20	25
	Likely (4) Once a week.	4	8	12	16	20
	Moderate (3) Once a month.	3	6	9	12	15
	Unlikely (2) Once a year.	2	4	6	8	10
	Rare (1) Once every 5 years.	1	2	3	4	5

Where:

Coliform (MPN)	Risk Score/Code	Risk/Rating (1 - 5)
0	< 6	No or low Risk
< 5	6 – 9	Moderate Risk
5 – 10	10 – 15	High Risk
> 10	> 15	Critical Risk

4. DISCUSSION

This study showed the growing reliance on rainwater harvesting in Buea due to shortages experienced in other sources especially pipe-borne water and the costly nature of borehole construction and commodification of such waters by the population. This growing reliance in rainwater has equally been investigated by similar studies (Hattum & Worm, 2006; Haut, et al. 2015; Heijnen, & Pathak, 2006).

In this study, microbial health risks associated with consumption of untreated harvested rainwater were estimated using the observed *E. coli* and *Salmonella spp.* Data, and the sanitary assessment of the RRWHS. All *E. coli* and *Salmonella spp*. data from different systems were combined, processed and analyzed to derive a set of risks ratings which were inputted in the model. The output of the model i.e., disease burden has been expressed in low, moderate, high and critical risks as recommended by (WHO, 2016), which is the globally applied Metrix used for comparing different disorders and diseases with different health outcomes. The microbial burden was estimated for three reference pathogens like TC, *E. coli* O157:H7 and *Salmonella spp* for bacterial diseases, in order to estimate total disease burden. The estimated disease burdens associated with the rainwater harvesting are illustrated in Table 3. It implies that microbial contamination of harvested rainwater account for a significant risk burden of waterborne diseases. Microbial hazards are more commonly associated with greater levels of health risk than chemical hazards (PACN, 2010). In developing countries, microbial hazards account for a very significant proportion of disease burden(Xavier, Siqueira, Vital, Rocha, Irmão, & Calazans, 2011). Diseases due to microbial hazards from poor water supply, sanitation and hygiene are responsible for an estimated 3.7% of the total global burden of disease.

However, rainwater harvesting may significantly increase the microbial health risk of the people in the water deficient areas in Buea, if the systems will not be properly operated and maintained. Therefore, potential of rainwater harvesting in reducing health risk and delivering safe water would need significant attention of the possible routes and causes of microbial contamination in order to ensure bacteriological quality of harvested rainwater. There are few reported outbreak investigations that have linked illness to tank rainwater consumption. This may be because the rainwater system usually supplies water only a few persons in a household, therefore sporadic cases of illness will be more likely to result rather than an outbreak. A study reviewed by Lye (2002) identified the diseases attributed to the consumption of untreated rainwater include bacterial diarrheas due to Salmonella and Campylobacter, bacterial pneumonia due to Legionella, botulism due to Clostridium, tissue helminths and protozoal diarrheas from Giardia and Cryptosporidium. In contrast to these, others have reported rooftop harvested rainwater to be of acceptable quality for drinking and cooking, presenting no increased risk of gastro-intestinal illness on consumption when compared with chlorinated and filtered public main water (Heyworth 2001). Thus, a clear consensus on the quality and health risk associated with roof top rainwater harvesting has not been reached yet.

5. CONCLUSION

Rainwater harvesting is increasingly being used as alternative to the erratic pipe-borne water in many quarters in Buea as well as the prohibitive cost of borehole construction which makes it inconveniencing and expensive for households without such schemes to conveniently access such water supplies. However, the overreliance on rainwater harvesting without adequate safety or quality control measures can present serious public health concerns. The presence of fecal indicator organisms in harvested rainwater (HRW) renders it unhealthy for drinking purpose, thus, untreated rainwater, thus microbial health risk would need proper attention for the safe and sustainable rainwater harvesting in Buea sub-division. It is safer for domestic activities, agricultural and construction purposes but may require some degree of pre-treatment and sanitary checks of the harvesting system for drinking water purpose.Based on the literature reviewed and the findings the researcher recommends the following:first, periodic treatment of rainwater with chlorine or bleach is recommended as an essential aspect that can improve on its quality or boiling harvested water before drinking; and, the population should be sensitized on health risks associated in the consumption of untreated rainwater.

REFERENCES

Al-Batsh, Al-Khatib, N., Ghannam, I. A., S., Anayah, F., Jodeh, S., Hanbali, G. & Valk, M. V. (2019). *Assessment of Rainwater Harvesting Systems in Poor Rural Communities: A Case Study from Yatta Area.* Palestine: *MDPI AG*.

Battenberg, G. E. (2009). *Flowing Issues A Brief History of Rainwater Harvesting.* Retrieved on the 14th of September 2009 from wcponline.com: http://www.wcponline.comflowing-issues-brief-history-rainwater-harvesting/

BMC. (2012). *Buea Communal Development Plan (CDP).* BUEA: National Communitydriven Development Program (PNDP).

Cleanawater. (2015). *Rainwater Harvesting Solutions: Which Countries Lead the Way?* Retrieved on the 4th of December from cleanawater.com.au: https://cleanawater.com.au/information-centre/rainwater-harvesting-solutions-which-countries-lead-the-way.

Cowie, A. (2018). *Ancient Rainwater Harvesting: It Fell From The Sky and Became Worshiped by Every Civilization.* Retrieved on the 26th of October 2019 from ancient-origins.net: https://www.ancient-origins.net/history-ancient-traditions/ancient-rainwater-harvesting-0010904.

Gur, E., & Spuhler, D. (2019). *Rainwater Harvesting (Rural).* Retrievedon the 13th of June 2018 from sswm.info: https://sswm.info/sswm-solutions-bop-markets/affordable-wash-services-and-products/affordable-water-supply/rainwater-harvesting-%28rural%29.

Hattum, T. V. & Worm, J. (2006). *Rainwater harvesting for domestic use*. Wageningen: Agromisa Foundation and CTA.

Haut, B., Zheng, X., Mays, L., Han, M., Passchier, C. & Angelakis, A. N. (2015). *Evolution of rainwater harvesting*. In e. W. J. H. Willems & H. P. J. van Schaik, *Water and Heritage: Material, Conceptual, and Spiritual Connections* (pp. ch. 3, pp. 37–56.). The Netherlands: Sidestone Press.

Heijnen, H. & Pathak, N. (2006). *Rainwater harvesting quality, health and hygiene aspects: International Workshop on Rainwater*. Sri Lanka: Kandy.

Hill, R. (2019). *Bacterial Activity in Harvested Rain Water*. Bucks, UK: Whitewater Ltd.

Julius, J. R., Prabhavathy, R. A. & G.Ravikumar. (2013). Rainwater harvesting (RWH) - A REVIEW. *International Journal of Scientific & Engineering Research.* Volume 4, Issue 8, 276.

Lambi, C. M. & Kometa, S. S. (2009). An Evaluation of Water Resources on the Eastern Slopes of Mount Cameroon. *Journal of Human Ecology*, 28(1) p. 47-55.

Lye, D. J. (2002). Health risk associated with consumption of untreated water from household roof catchment system. *Am. Water Res. Assoc.*, 38(4), 1301–1306.

Mbua, R. L. (2013). Water Supply in Buea, Cameroon: Analysis and the Possibility of Rainwater Harvesting to stabilize the water demand. *Research Gate*. 26.

Molua, E. L. & Lambi, C. M. (2006,). *Climate Hydrology and Water Resources in Cameroon*. Retrieved on the 24th of January 2018 from researchgate.net: https://www.researchgate.net/publication/266448446.

Namrata, P. & Han, H. (2006). *Rainwater Harvesting and Health Aspects - Working on WHO guidance* . Colombo, Sri Lanka: WEDC, Loughborough University.

Oxoid. (2019). *Dehydrated Culture Media*. Retrieved on the 29th April 2018 from oxoid.com:http://www.oxoid.com/UK/blue/prod_detail/prod_detail.asp?pr=CM0968&org=71&c=UK&lang=EN.

PACN. (2010). *Africa's Water Quality: A Chemical Science Perspective.* Piccadilly, London: Royal Society of Chemistry.

Renewable Energy Hub (2018). *History of Rainwater Harvesting*. Retrieved on the 12th of April 2018 from renewableenergyhub.co.uk:https://www.renewableenergyhub.co.uk/main/rainwater-harvesting-information/history-of-rainwater-harvesting.

Rochat, E. (2019). *The History of Rainwater Harvesting.* Retrieved on the 18th of April 218 from perfectwater.com: https://4perfectwater.com/blog/the-history-of-rainwater-harvesting.

Sayana, V. B., Arunbabu, E., Kumar, L. M., Ravichandran, S. & Karunakaran, K. (2010). Groundwater Responses to Artificial Recharge of Rainwater in Chennai, India: a Case Study in an Educational Institution Campus. *Indian Journal of Science and Technology*, Volume 3; Issue 2.

Schets, F. M., Italiaander, R. & Berg, H. H. (2010). Rainwater harvesting: quality assessment and utilization. *Journal of Water and Health*. 224.

Singh, R. K. (2017). Beneficial impacts of rain water harvesting in Chhattisgarh. *International Journal of Advance Engineering and Research Development (IJAERD)*, 1.

Suh, L. (2016). Addressing the Human Rights Issues of Water and Sanitation in Fako division (Cameroon): Legal Framework and the Realization of the Sustainable Development Goals. *theseus.fi*.

UNDP (2019). *Sustainable Development Goal - Goal 6: Clean Water and Sanitation*. Retrieved on the 19th of March 2019 from undp.org: http://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-6-clean-water-and-sanitation.html

UNEP. (2001). *Rainwater harvesting and utilization : an environmentally sound approach for sustainable urban water management : an introductory guide for decision-makers*. Retrieved on the 8th of January 2019 from unep.or.jp: http://www.unep.or.jp/ietc/publications/urban/urbanenv-2/index.asp.

WHO. (2016). *Quantitative Microbial Risk Assessment: Application for Water Safety Management.* Geneva, Switzerland: WHO Document Production Services.

Xavier, R. P., Siqueira, L. P., Vital, F. A., Rocha, F. J., Irmão, J. I. & Calazans, G. M. (2011). Microbiological quality of drinking rainwater in the inland region of Pajeú, Pernambuco, Northeast Brazil. *Scielo Analytics*.

Zavala, M., Prieto, M. & Rojas, C. (2018). *Water Supply. In Rainwater harvesting as an alternative for water supply in regions with high water stress* . Mexico: Water Science & Technology.

UN (2019). *Sustainable Development Goals*. Retrieved on the 5th of January 2019 from un.org: https://www.un.org/sustainabledevelopment/water-and-sanitation/