International Journal Of Engineering Research And Development
e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 14, Issue 9 (September Ver. I 2018), PP.50-56

Quality Assessment of Rainwater Harvested From Corrugated Zinc Roofs Stored In Ferro-Cement Reservoirs

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ABSTRACT:*Rain water harvesting is an important source of water supply for places that experience low rainfall. This study focuses on the quality of rain water harvested from corrugated zinc roof and stored in ferro-cement reservoirs fromresidential locations in Ovia North-East Local Government of Edo State. Standard laboratory procedures were used to determine the microbiological and physicochemical parameters of the rain water collected from ferro-cement reservoirs. These parameters were compared with the recommended limits prescribed by the Nigerian Standard for Drinking Water Quality (NSDWQ) and World Health Organization (WHO). All the physicochemical parameters were within the permissible water quality standards recommended by (NSDWQ) and (WHO) except pH which were slightly alkaline. The microbiological parameters such as E-coli and total coliform were above the prescribed limits of NSDWQ and WHO. This implies that the rain water should be treated to make it safe for drinking.*

KEYWORDS:*Ovia North-East, Nigeria, Water Quality, Physicochemical, Microbiological*

Date of Submission: 03-11-2018 Date of acceptance: 17-11-2018

I. INTRODUCTION

UNICEF and WHO (2012) reported the non-availability of drinking water to about 780 million people in the world, withmost of these people living in developing countries. Urban and rural areas in Nigeria,are experiencing water supply shortfall, attributed to increase in population among other factors (Adeboye and Alatise 2008). Rainwater collection can help meet the demands for water by rural communities (Pacey and Cullis, 1986) and provide supplement water for urban areas (Devi et al., 2012; Gould and Mcpherson, 1987). Rainwater harvesting (RWH) can be considered as any human activities that involves the collection and subsequent storage of rainwater in man-made or natural container for diverse purposes (Kun et al., 2004). The concept of RWH schemevaries from a simple set up as an attachment of a water bucket to a rainwater downspout to a large system for water collection from numerous hectares (UNEP, 1982). In rural localities, the most common identified method for rainwater harvesting is the small-scalerooftop (Pacey and Cullis, 1986). Although RWH improves water supply, it has been reported by several researchers that it may constitute a risk to public health risk due to the possibilities to carry microbial pathogens (Ahmed et al., 2008, 2011; Simmons et al., 2011).The quality of rainwater has been linked directly to atmospheric condition, quality and cleanliness of material used for catchment surface, gutters and storage tanks (Lee et al., 2010).

Roof type materials are closely related to rainwater water quality, as can be observed from the works of several researchers (Lee et al., 2012; Sanchez et al., 2011; Mendez et al., 2015; Olaoye and Olaniyan, 2012; Yaziz et al., 1989;Achadu,(2013). A reasonably quality of water can be obtained from clean rooftop made from non-toxic materials with the initial water runoff for a given rainfall at the start of the event, diverted from the storage container (Lekwot et al., 2012; Kuntala et al., 2011; World Health Organisation (WHO), 2004).Eradication of diseases associated with the availability of safe, adequate and affordable water supplieshas a significant positive impact on the economy of the individual, community and the nation (Theron and Cloete 2002; Ashbolt 2004; Eshelby 2007; de Kwaadsteniet et al, 2013). The transmission of water borne diseases in Africa and other parts of developing countries is primarily associated with poor water quality (Ongley, 1999). An estimation of about 80 per cent of all diseases and well over one third of deaths indeveloping countries occur as a result of the consumption of contaminated water (UNCED, 1992). While in the work of Tobin et al., (2013), it was reported thatfive million death recorded annually was caused by water-related disease with about four million deaths (400 deaths per hour) been children below age of 5 years. These has necessitated the need for proper examination of rain water quality consume by communities in several areas byresearchers (Egwuogu et al., 2016; Tobin et al., 2015; Okoye et al., 2011; Lekwot et al., 2012). Water quality monitoring provides information useful in water quality surveillance, forecasting water quality and collection of baseline data in any community or country(Ekiye and Luo, 2010).The aim of this study is to investigate the physicochemical and microbiological water quality parameters of rain water harvested from corrugated zinc roof and stored in ferro-cement reservoirs in residential zones ofOvia North-East local government area. Theobtained parameters values were compared to the desirable limits as prescribed by NSDWQ and WHO.

II. MATERIALS AND METHODS

2.1Study Area

This study was carried out in Ovia North-East Local Government Area of Edo State during the month of September. The local government area lies between latitudes 5^0 40^l and 7^0 40^1 and longitude 5^0 00^l and 6^0 30^1. The region has an area of 2301Km^2 and a population of 153,849 at the 2006 census. The administrative centre of Ovia North-East Local Government Area is Okada town. The map of the study area is shown in Figure 1.

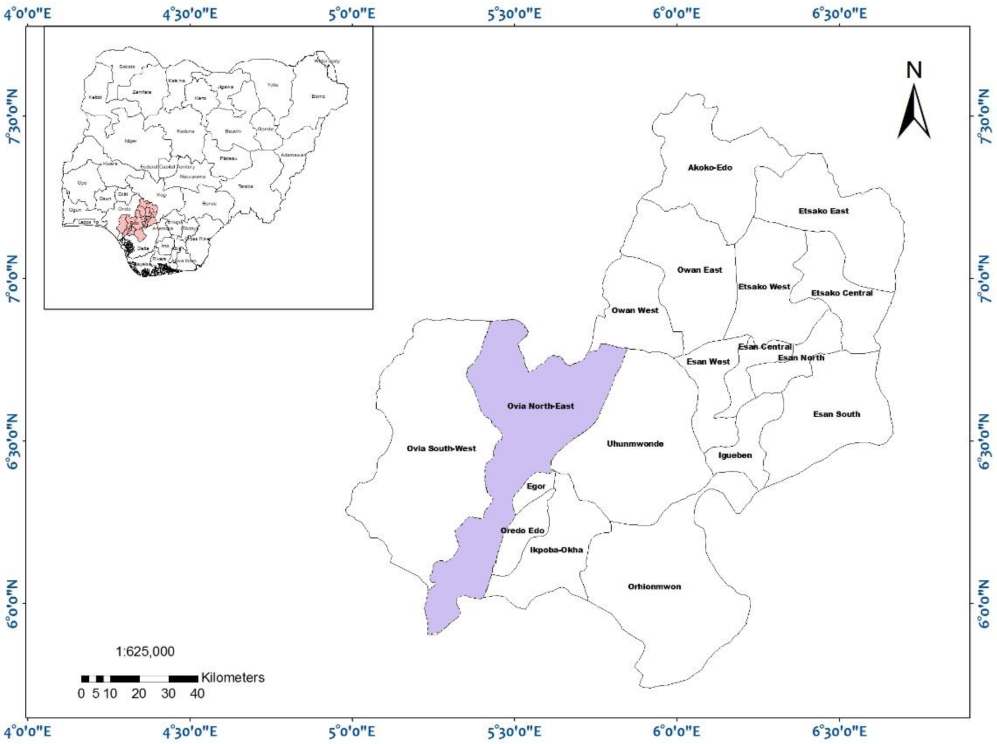

Figure 1. Map of Edo state showing Ovia North-East Local Government Area

2.2Sample Collection and Laboratory Tests

Rooftop harvested rainwater was collected from ground reservoirs of three residential houses in the study area. The reservoirs were lined with mortar and covered with concrete slab and metal sheet at the opening for water extraction. The roof of each house was covered with zinc sheets. The conveyance systems of each reservoirs consist of an aluminum funnel fitted directly into a vertically erected PVC pipe placed at the edge of a roof gutter made of zinc material. At the bottom of the vertical plastic pipe, a horizontal pipe was connected to the vertical plastic pipe and channeled directly to the ground reservoir. Three stations (top, middle and bottom) were established in each reservoir for collection of water samples. In the sample collection, a metallic bucket with a small opening at the top covered with a lid was used. Ropes were tied to the lid and bucket respectively. The bucket was lowered to each station and the lid was opened by pulling up the rope tied to the lid to allow the entry of water. Sterile containers were used to collect the samples of water from the metallic bucket and then transported to the laboratory for analysis.Taste and odour were measured using the human sense of taste and smell. Colour and turbidity were measured using a hach calorimeter. A high-powered microcomputer conductivity meter Jenway 40710 model HI 9032 was used to measure conductivity and total dissolved solids, while the pH meter Jenway 3071 model equipped with temperature probe was used to measure the pH. Alkalinity was determined using methyl orange and hydrochloric acid solution. The biochemical oxygen demand (BOD) was measured using the Winkler method after storing the samples in an incubator for five days. The Winkler method was used to determine the dissolved oxygen.

III. RESULTS AND DISCUSSIONS

3.1Physical Parameters of Stored Rainwater

The results for the physicochemical analyses of harvested water stored in ferro-cement reservoir from OviaNorth East Local Government Area is presented in Table 1.

Table 1. Summary results for the Stored rainwater parameters

Parameters	Unit	Mean	S.D	Min	Max	NSDWQ	WHO
Taste	tasteless					unobjectionable	unobjectionable
Odour	odourless					unobjectionable	unobjectionable
pH	pH-unit	8.88	0.33	8.40	9.30	6.5-8.5	6.5-8.5
Conductivity	uS/cm	46.11	5.23	38.00	51.00	1000	1500
Turbidity	NTU	2.67	1.00	1.00	4.00	5	5
Colour	TCU	10.00	1.58	8.00	12.00	15	15
Alkalinity	mg/l	19.00	3.20	14.00	24.00		100
Hardness	mg/l	21.11	4.59	16.00	28.00	150	150
Dissolved oxygen		5.10	0.35	4.58	5.50	5	5-10
BOD5	mg/l	3.01	1.14	1.50	3.90	5	5
Total dissolved solids	mg/l	28.19	9.99	3.70	36.00		0-500
Total coliform	cfu/100ml	1.22	0.44	1.00	2.00	0	0
E-coliform	cfu/100ml	1.00	0.00	1.00	1.00	0	0

Figure 2 shows the mean values of the pH of the stored harvested rainwater. The average pH value of sample A(9.0) and B(9.1) were greater than the recommended values from NSDWQ and WHO. Only sample C(8.5) was within the acceptable limits. This implies that the roof harvested water from the reservoirs were alkaline in nature. Since there is no industrial activity in the study area, it can be concluded that the major source of alkalinity can be attributed leaching of the cement constituents in the ferro-cement reservoirs. This observation is in accordance with the findings of Thomas (2009), where the recorded pH of ordinary Portland cement and pozzolanic Portland cement storage tanks after 54weeks were 10.37 and 10.54 respectively.

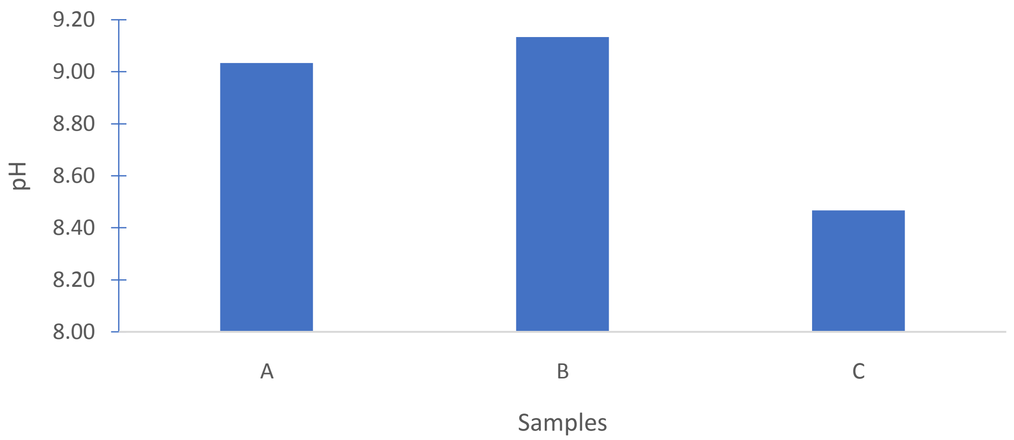

Figure 2. Mean values of pH of the stored rainwater samples.

In Figure 3, the turbidity values of the samples from the reservoirs were below NTU 5, which indicates that their turbidity are within the acceptable limits specified by NSDWQ and WHO as shown in Figure 3.

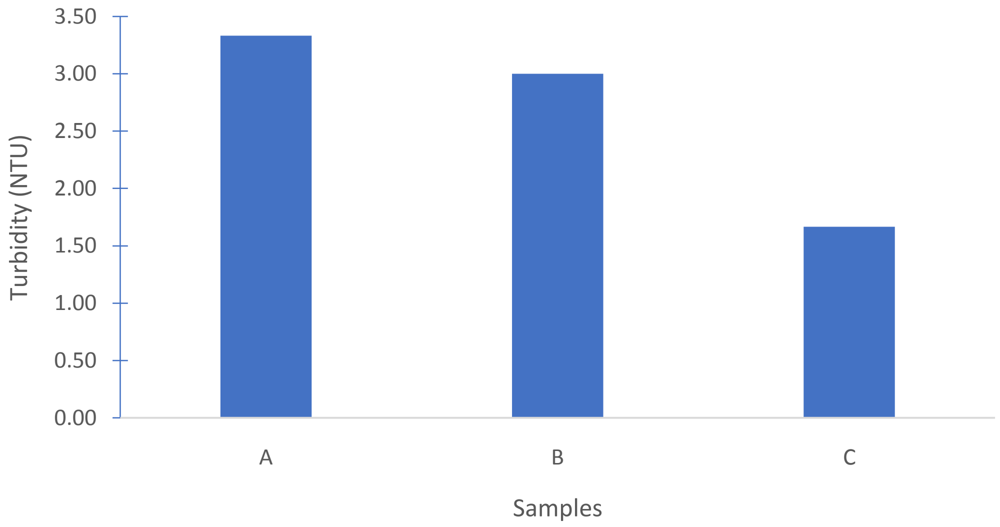

Figure 3. Mean values of turbidity of the stored rainwater samples.

The mean electrical conductivity values of the water samples measured is showed in Figure 4. Samples A and B had conductivity values of 50µs/cm and 49 µs/cm respectively. Sample C had a lower conductivity value of 39 µs/cm. Thus, the conductivity values for all the water samples are very low as far as WHO and NSDEQ guidelines for drinking water quality are concerned.

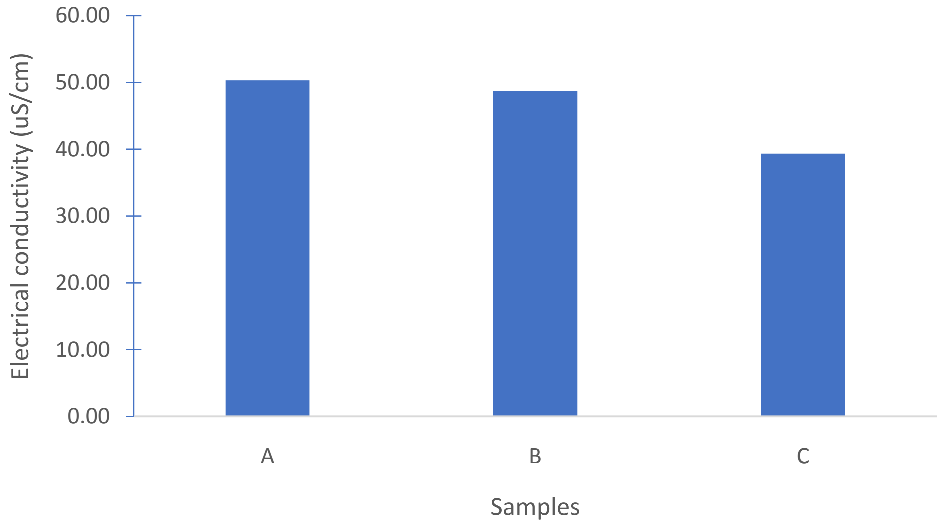

Figure 4. Mean values of electrical conductivity of the various stored rainwater samples.

The mean values of the colour obtained for each of the water samples were 9TCU, 11TCU and 10 TCU for samples A. B and C respectively as shown in Figure 5. These results were below the maximum limit of 15TCU prescribed by NSDWQ and WHO.

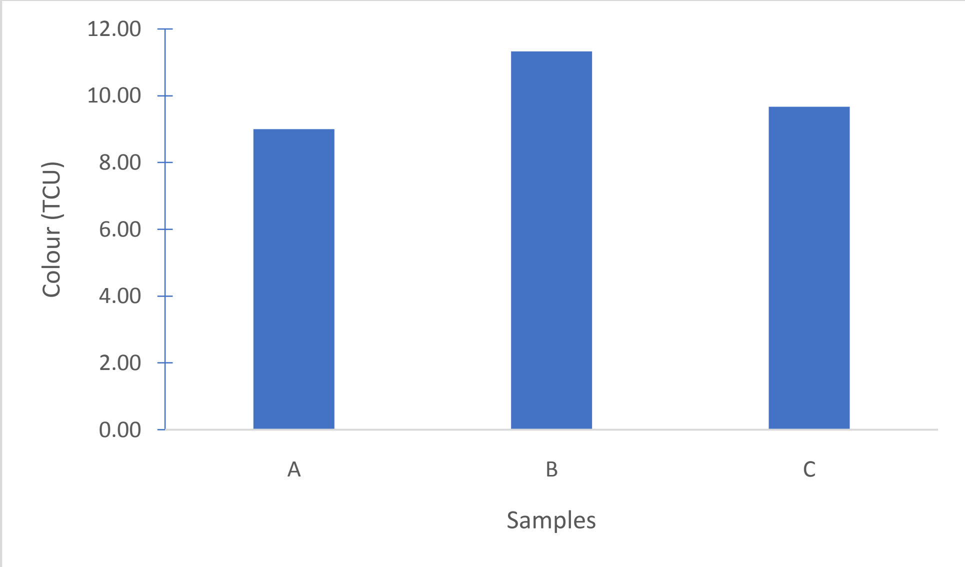

Figure 5. Mean values of colour of the various stored rainwater samples.

The mean values of alkalinity, water hardness, dissolved oxygen, biochemical oxygen demand and total dissolved solids of the water samples is presented in Figure 6. The average alkalinity of the water samples varied between 16mg/l and 22mg/l and is well within the WHO stipulated limit

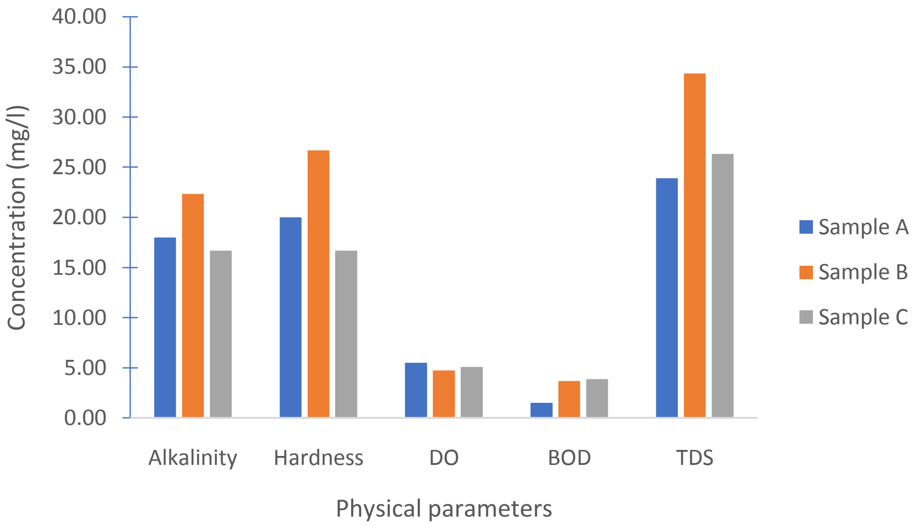

Figure 6. Mean values of alkalinity, hardness, dissolved oxygen, biochemical oxygen demand and total dissolved solids means of the various stored rainwater samples.

The total hardness concentration for samples A,B and C obtained showed that sample B had the highest value of total hardness concentration while sample C had the least value. The water hardness for the three water samples are low and in compliance with the standards of NSDWQ (150mg/l). Also, the results obtained for the water samples for the dissolved oxygen showed that sample A has the highest value of dissolved oxygen (5.48mg/l), while sample B and C had 4.7mg/l and 5.08mg/l respectively. These results are within minimum standard for WH water quality. While the biochemical oxygen demand for sample C was the highest with a BOD_5 value of 3.86mg/l. Sample A had the least value of BOD_5 of 1.5mg/l and sample B had BOD_5 of 3.67mg/l. These values are less than the max 5mg/l prescribed by NSDWQ and WHO. The total dissolved solids for all sample were 35mg/l, 34mg/l and 26mg/l for samples A, B and C respectively.

IV. MICROBIOLOGICAL PARAMETERS

The laboratory test results obtained for the microbiological water quality parameters for the three water samples is presented in Figure 7.

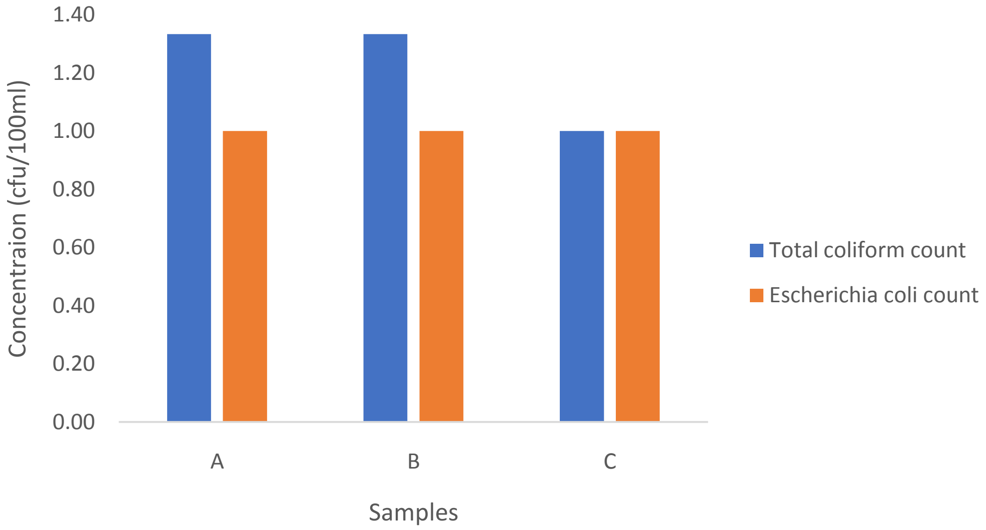

Figure 6. Mean values of total coliform and Escherichia coli of the stored rainwater samples.

It can be observed that the total coliform and E-coli count of the water samples from the various locations were above the standard requirements by WHO and NSDWQ. This observation was similar to finding in a rural community by Tobin et al., (2013) andMagnus, (2011). Escherichia coli and total coliform are common indicators of disease-causing pathogens (Ahmed et al. 2017; Jang et al. 2017). Detection of the presence of E-coli in water is taken as evidence of recent pollution with human or animal feces, while coliform organisms in water indicates that some portion of the water has been in contact with soil or decaying vegetation or has been through the intestinal tract of a warm-blooded animal. The harvested water requires treatmentbefore it can be totally safe for drinking.

V. CONCLUSION

The physicochemical and microbiological assessment of rain water sample harvested from corrugated zinc roof catchment and stored in ferro-cement reservoirs showed that all the physicochemical parameters determined were within the prescribed limits of WHO and NSDWQ excerpt for pH and the microbiological parameters. The high pH values of the water samples,implies alkalinity in nature. The absence of industrial activities in the area under study, indicate that the major source of alkalinity can be attributed to leaching of the cement constituents in the ferro-cement reservoirs.A major source of concern is the high values of microbiological parameters of the stored harvested rain water. Escherichia coli and total coliform were above the prescribed limits of NSDWQ and WHO. Escherichia coli and total coliform are common indicators of disease-causing pathogens. It can be concluded that fecal deposition on the catchment surface is the major source of microbial contamination, hence the harvested rainwater should be treated before it can be safe for drinking.

REFERENCES

[1]. Achadu, O.J., Ako, F.E. and Dalla, C.L., (2013). Quality assessment of stored harvested rainwater in Wukari, North-Eastern Nigeria: Impact of storage media. Journal of Environmental Science, Toxicology and Food Technology,vol. 7, Issue 5, pp. 25-32.

[2]. Adeboye, O.B. and Alatise, M. O., (2008). Surface water potential of River Osun at Apoje Sub-Basin, Nigeria. Soil Water Res 3(2):74–79.

[3]. Ahmed, W., Gardner, T., and Toze, S., (2011). Microbiological quality of roof-harvested rainwater and health risks: a review. Journal of Environmental Quality, 40(1), 13–21.

[4]. Ahmed, W., Huygens, F., Goonetilleke, A., and Gardner, T. (2008). Real-time PCR detection of pathogenic microorganisms in roof-harvested rainwater in Southeast Queensland, Australia. Applied and Environmental Microbiology, 74(17), 5490–5496.

[5]. Ahmed, W., Staley, C., Hamilton, K. A., Beale, D. J., Sadowsky,M. J., Toze, S., and Haas, C. N. (2017). Amplicon-basedtaxonomic characterization of bacteria in urban and peri-urbanroof-harvested rainwater stored in tanks. Science ofthe Total Environment, 576, 326–334.

[6]. Ashbolt, N. J., (2004). Microbial contamination of drinking water and disease outcomes in developing regions. Toxicology, 198, 229–238.

[7]. de Kwaadsteniet, M.,Dobrowsky, P. H.,van Deventer, A., Khan, K. and Cloete, T.E., (2013). Domestic rainwater harvesting: Microbial and chemical water quality and point-of-use treatment systems. Water Air Soil Pollut, 224:1629.
[8]. Devi, R., Diboch, B., and Singh, V., (2012). Rainwater harvesting practices: key concept of energy-water linkage for sustainable development. Sci Res Essays. 7(5):538-43.
[9]. Egwuogu, C.C., Okeke, H.U., Emenike, H.I. andAbayomi,, T.A.,(2016). Rainwater quality assessment in Obio/Akpor LGA of River State Nigeria.International Journal of Science and Technology Volume 5 No. 8, pp.374-381.
[10]. Ekiye, E. and Luo, Z., (2010). Water quality monitoring in Nigeria; Case Study of Nigeria's industrial cities. Journal of American Science.6(4)22-28
[11]. Eshelby, K., (2007). Dying for a drink. British Medical Journal, 334, 610–612.
[12]. Gould, J.E. and McPherson, H.J., (1987). Bacteriological quality of rainwater in roof and groundwater catchment systems in Botswana. Water Int. 12:3, 135-138.
[13]. Jang, J., Hur, H.G., Sadowsky, M.J., Byappanahalli, M.N., Yan,T., and Ishii, S. (2017). Environmental Escherichia coli: ecologyand public health implications—a review. Journal ofApplied Microbiology 123(3), 570–581.
[14]. Kun, Z., Linus, Z., William, H., Mancang, L. and Hui, C., (2004). Quality issues in harvested rainwater in arid and semi-arid Loess Plateau of northern China, J. Arid Environ. 57(4):487-505.
[15]. Kuntala, R., Hironmoy, R., Chakraborty, M. and Biswas, R., (2011). Exploratory study on water quality and sanitary practices in rural and urban communities of Siliguri, Darjeeling , West Bengal. Indian j Prev. Soc. Med. 42(2), pp. 199-203
[16]. Lee, J. Y., Bak, G. and Han, M., (2012). Quality of roof-harvested rainwater – Comparison of different roofing materials. Environmental Pollution, 162, 422–429.
[17]. Lee, J. Y., Yang, J. S., Han, M., and Choi, J., (2010). Comparison of the microbiological and chemical characterization of harvested rainwater and reservoir water as alternative water resources. Science of the Total Environment, 408, 896–905.
[18]. Lekwot, V.E., Ikomomi, S., Ifeanyi, E. andOnyemelukwe, O., (2012). Evaluating the potential of rainwater harvesting as a supplementary source of water supply in Kanai (Mali) district of Zangon-kataf local government area of kadunastate , Nigeria. Global Adv. Res. J. Environ. Sci. Toxicol. 1(3):38-45.
[19]. Magnus, O.O., (2011). Assessment of rainwater harvesting facilities in Esan land of Edo state, Nigeria. J. Hum. Ecol. 34(1):7-16.
[20]. Mendez, C. B., Klenzendorf, J. B., Afshar, B. R., Simmons, M. T., Barrett, M. E., Kinney, K. A. and Kirisits, M. J. (2011). The effect of roofing material on the quality of harvested rainwater. Water Research, **45**(5), 2049–2059.
[21]. National Standard of Drinking Water Quality (NSDWQ) (2007). Nigeria Standard for Drinking Water Quality, Nigeria Industrial Standard, Approved by Standard Organization of Nigeria Governing Council. ICS 13. 060. 20:15-19.
[22]. Okoye A. C., Oyemi, E. A., Oladipo., A. A., Ezeonu, F. C., (2011). Physicochemical analysis and trace metal levels of rain water for environmental pollution monitoring in Ile-Ife, Southwestern Nigeria. J. Int. Environmental Application Science. 6(3):326-331.
[23]. Olaoye, R.A. and Olaniyan, O.S., (2012). Quality of rainwater from different roof material. International Journal of Engineering and Technology, **2**(8), 1413–1421.
[24]. Ongley, E.D., (1999). Water quality management: design, financing and sustainabilityconsiderations. Proceedings of the African Water Resources Policy Conference, Nairobi,May 26-28, The World Bank (in press).
[25]. Pacey, A. and Cullis, A., (1986). Rainwater harvesting: The collection of rainfall and run-off in rural areas. Intermediate Technology Publications Ltd.
[26]. Sánchez, A. S., Cohim, E. and Kalid, R. A., (2015). A review on physicochemical and microbiological contamination of roof-harvested rainwater in urban areas. Sustainability of Water Quality and Ecology, **6**, 119–137.
[27]. Simmons, G., Hope, V., Lewis, G., Whitmore, J., and Gao, W., (2011). Contamination of potable roof-collected rainwater in Auckland, New Zealand. Water Research 35 (6), 1518-1524.
[28]. Theron, J., and Cloete, T. E. (2002). Emerging waterborne infections: contributing factors, agents, and detection tools. Critical Reviews in Microbiology, 28, 1–26.
[29]. Thomas, R. M., (2009). Studies on the quality of rainwater at various land use locations and variations by interaction with domestic rainwater harvesting systems". Doctor of Philosophy Thesis submitted to Cochin University of Science and Technology.
[30]. Tobin, E. A., Ediagbonya, T. F., Ehidiamen, G. and Asogun, D. A., (2013). Assessment of rain water harvesting systems in a rural community of Edo State, Nigeria. Journal of Public Health and Epidemiology. Vol. 5(12), pp. 479-487.
[31]. UNCED (1992). Protection of the Quality and Supply of Freshwater Resources: Application of Integrated Approaches to the Development, Management and Use of Water Resources. The United Nations Conference on Environment and Development. Chapter 18, Agenda 21.
[32]. United Nations Environmental Programme (UNEP) (1982). Rain and Storm Water Harvesting in Rural Areas. Dublin: Tycooly International Publishing Limited.
[33]. UNICEF and WHO. (2012). Progress on drinking water and sanitation. 2012 Update WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, WHO Library Cataloguing-in-Publication Data.
[34]. World Health Organization, (2004). Guidelines for drinking water. WHO; Geneva.
[35]. WHO, World Health Organization, (2011).Guidelines for Drinking-water Quality. (Fourth
[36]. edition) Geneva 27, Switzerland
[37]. Yaziz, M. I., Gunting, H., Sapari, N. and Ghazali, A. W., (1989). Variations in rainwater quality from roof catchments. Water Research, 23(6), 761–765.

Oria-Usifo, E.E. "Quality Assessment of Rainwater Harvested From Corrugated Zinc Roofs Stored In Ferro-Cement Reservoirs "International Journal of Engineering Research And Development , vol. 14, no. 09, 2018, pp. 50-56