Asia Pacific Environmental and Occupational Health Journal (ISSN 2462 -2214), Vol 3 (1): 44 – 51, 2017
Published online © 2017 Environmental and Occupational Health Society

Effects of Roofing Materials on Harvested Rain Water Quality in Minna, Nigeria.

Musa JJ[1], Anijiofor SC[2, 3], Saidu M[4], Bake GG[5].

[1]*Department of Agricultural & Bioresources Engineering, Federal University of Technology, Minna, Nigeria.*
[2]*Department of Civil Engineering, Federal Polytechnic, Birnin Kebbi, Nigeria.*
[3]*Department of Civil Engineering, Faculty of Engineering, Universiti Putra Malaysia, Selangor, Malaysia.*
[4] *Department of Civil Engineering, Federal University of Technology, P. M. B. 65, Minna, Nigeria.*
[5]*Department of Water Resources, Aquaculture & Fisheries Technology, Federal University of Technology, Minna, Nigeria*

Corresponding author: Anijiofor SC; sandee4jesus@yahoo.com; Department of Civil Engineering, Federal Polytechnic, Birnin Kebbi, Nigeria; +2348036209233, +60172772335.

ABSTRACT

Objective: Scarcity of conventional sources of water in arid and semiarid regions has promoted the search for additional sources of water. This study is aimed at assessing the level of portability of rainwater samples harvested from zinc and aluminium coated roofing materials of some residential homes located in a non-commercial centre in Minna, Nigeria.

Method: Ten residential homes which had the requirements for the study, comprising the two materials were identified. Samples were collected once every week between the months of June and September for the years 2010, 2011 and 2012 respectively. A comprehensive physicochemical analysis was carried out on the sample and their averages taken.

Result: Electrical conductivity ranged between 232 and 432 µs/cm; total dissolved solid ranged between 38.9 and 47.8 mg/L; total alkalinity ranged between 16.5 and 52 mg/L while the zinc content ranged between 1 and 2 mg/L. No aluminum deposits were observed from the study area.

Conclusion: All the physiochemical parameters tested were within the recommended specification of NSDWQ of 2007 thus the harvested rainwater can be used for domestic and agricultural purposes.

Keywords: *aluminum, harvested rainwater, zinc, water quality, parameters.*

1. Introduction

Man realized from the very beginning that water is about the most essential element for satisfaction of all his basic needs. Water is the essence of life and safe drinking water is a basic human right essential to all. It is essential for the wellbeing of mankind and for sustainable development (Xiaoyan et al., 2002; Musa and Ahanonu, 2013; Musa et al., 2013). As urban population increases, the need for the basic amenities of life increased, which includes homes and the need for water increases. With the unprecedented growth rate in the world population, a large amount of chemical compounds are released into our environment which affects the chemical composition of such areas, thus causing the emergence of new health hazards which in some cases cause life threatening diseases and climate changes at a global scale. The atmosphere according to several researchers is subject to photochemical reactions and the transportation of such over longer distances (Daum et al., 1996; Maliszewska-Kordybach, 1999; Despins et al., 2009; El Atta et al., 2010). During the cause of rainfall, some of these compounds are dissolved and wash out as gases and aerosols together with the compounds contained in them (Kus et al., 2011; Cobbina et al., 2013; Pokowska, 2014). The unavailability of this essential fluid of life in adequate quantity and quality in some cases delays development. Without water, humans cannot live for more than a few days. Water is in great demand as it represents a unique feature in every settlement: for drinking, sanitation, washing, fishing, recreation and industrial processes. Assess to clean and regular water supply is a basic human right as is access to unadulterated food. A lot of people especially the less affluent however miss out on this as with other human rights (Radaideh et al., 2009; Achadu et al., 2013).

Harvested rainwater is the most commonly used water for domestic purposes in most developing countries of world as the available water is not sufficient to meet the growing needs (Moglia, 2010; Olaoye and Olaniyan, 2012; Aydin, 2014). Rainwater can be a valuable resource and can be quite safe to drink when harvested and stored in a properly installed and maintained water catchment system (Zhu et al., 2004; Li et al., 2010; Mendez et al., 2010; Lee et al., 2012). Several researchers have stated that in many areas of the world today, this can either be the only source of water for the household, or more commonly a supplementary supply to ease the burden of water collection from other sources (Olaoye and Olaniyan, 2012; Lee et al., 2012). Roof top is one of the most common methods of collecting rain water which as existing roofs are used. The quantity and quality of rainwater collected depends mostly on the area and type of roofing material used such homes. Roofs provide an ideal catchment surface for harvesting rainwater; provided they are clean (Thomas, 1998; Mostafa and Shafiuzzman, 2008). Rainwater is a common source of meeting the need for adequate water supply in most homes (Mendez et al., 2010). This is a process whereby rain is intercepted by various types of roof tops before reaching the earth. In Nigeria, there are various types of roofing materials, some of which includes galvanized iron roofs, aluminum roofs and thatched roofs to mention but a few. Rainwater harvesting is a technology used to collect and store rain water from relatively clean surfaces such as roofs, land or rock catchments (Zhu et al., 2004; Li et al., 2010; Ishaku et al., 2012). The harvested water is usually stored in surface and underground tanks. Harvested water are mostly used to maintain constant supply for domestic and other kind of uses since it is believed that harvested rainwater is reasonably good if proper procedure coupled with proper installation and maintenance activities are carried out (Nicholson et al., 2009). The quantity and quality of rainwater harvested depends on the rain intensity, the surface area of the roof, the type of roofing material and the surrounding environment. Thus, it is generally believed to be cleaner and safer when compared to other sources of water (Kahinda et al., 2007; Eletta and Oyeyipo, 2008; Lye, 2009; Farreny et al., 2011).

Collected rainwater aside meeting the ever increasing demand for supply of water, helps reduce surface runoff and deposition of various types of materials in drains. These acts reduce flood hazards and reduce soil erosion (Saha et al., 2007; Kamar, 2015). This is according to some researchers is one the best ways of solving water deficit problems where there is inadequate water supply (Samuel and Mathew, 2008). Rainwater harvesting still remains the only source of potable water supply to most communities in Nigeria where there are no water supplies and where such exits harvested rainwater is still a major source for domestic use. It has been reported that various roofing materials used for the collection of water can be sources of non-point pollution. Some examples of materials used for roofing Nigeria includes galvanized sheets, corrugated iron sheets, corrugated plastic sheets, asbestos cement sheets, concrete, thatch, tile or clay. The quality of drinking-water is of utmost importance with respect to human and health. Thus, the management of the quality parameters of water can be a major key to the prevention of waterborne diseases (Farreny et al., 2011). The most predominant waterborne disease includes diarrhoea/dysentery which is believed to cause about 2.2 million deaths every year in developing countries (WHO, 2010).

The objective of this study was to carefully examine the effect of age of roofing material on the quality of harvested rainwater in Minna, from the standpoint of suitability for domestic use and to compare the obtained results with Nigerian Standard Drinking Water Quality (NSDWQ) and World Health Organization (WHO) standards.

2. Materials and Method

Minna, a non-commercial center and state capital of Niger State is the study area. It is a semi-arid town in the North central part of Nigeria. Figure 1 shows the map of Nigeria showing the extract of Niger State and Minna (Musa et al., 2012). The study area for this research lies in latitude 90 36’ 50’’N and longitude 60 33’25”. The population of Minna was estimated as at 2012 to 613,246.

Minna, generally is known to experience rainfall from the month of May to the month of October and on rear occasions, to November. It is known to reach its maximum peak between the months of July and August. Towards the end of the rainfall season, around October or November, it is known to be accompanied by great thunder storms

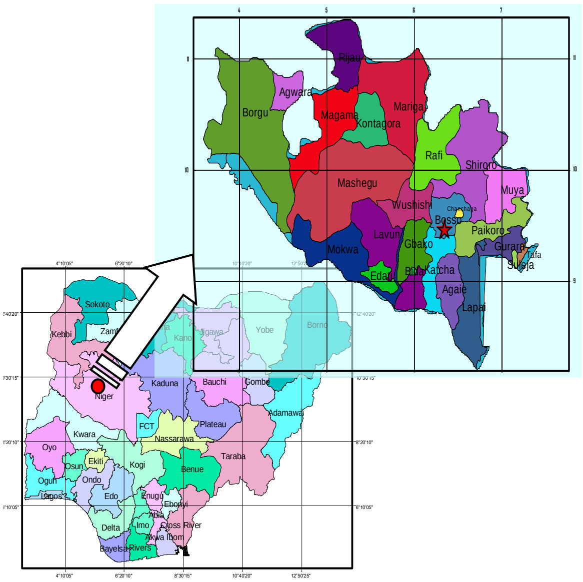

Fig 1. Map of Nigeria showing an extract of the study area, Minna.

Table 1 gives the maximum and minimum rainfall received in Minna. The maximum temperature period in this area is usually between the months of February, March and April which gives an average minimum temperature record as shown also in Table 1. During this rainfall periods, temperature within the area drops to about 19^0C.

Table 1: Climatic and Aquifer Conditions in Minna

Climatic Factors	Minimum	Maximum
Annual Precipitation	1100mm	1300mm
Daily Sunshine Hours	6.4	9.2
Average temperature	19^0C	40^0C
Evapotranspiration	25mm	90mm

Source: (Adesiji and Jimoh, 2012)

A total of ten water samples each were collected at atmospheric temperature for new galvanized roofs (age of less than six months), old galvanized roofs (age of roof not more than fifteen years), new aluminum roofs (age of less than six months) and old aluminum roofs (age of roof not more than fifteen years) from some selected location in Minna, Nigeria. This classification is similar to the works of (Akintola and Sangodoyin, 2011). The samples were collected during the months of May to August in the years 2010, 2011 and 2012. This is to ensure that all the roofs considered were within similar duration of usage to avoid biasness. Standard procedures of water sample collection were followed as stated by (NSDWQ, 2007) and (Musa et al., 2013). The control for this study was collected directly without any interception. The samples collected were kept in 1000 mL sterilized plastics bottles which were labelled and immediately stored at 4°C before transportation to the laboratory from the collection site. The codes used for labelling represented the location were the samples were collected from. During the selection of the area for which the water samples are to be collected, care was taken not to select areas where industrial activities and high population density areas were avoided as such areas may have the rain water contaminated before getting to the roofs. The samples were treated and analyzed based on standard procedures followed by according to (Olaniyi et al., 2018). Some of the parameters considered includes pH, alkalinity, Hardness, turbidity, Total Dissolved Solids (TDS), (COD), Nitrite (NO_2), Nitrate (NO_3), Ammonium (NH_4), Phosphate (PO_4), Lead (Pb), Iron (Fe), Chromium (Cr), Aluminum (Al), Fluoride (F), Chlorine (Cl), Copper (Cu), Color, hardness, Zinc (Zn), Sulphate (SO_4), and Mn.

3. Results

The results of the physical and chemical analysis carried out on rain water samples for the four roofing types of material (new galvanized roofs, old galvanized roofs, new aluminum roofs and old aluminum roofs) considered for this study are presented in Table 2.

4. Discussion

It is observed from the obtained results, that the physical parameters (color, appearance, odor, taste) were colorless and un-objectionable for the four types of roofing materials considered. These results were in conformity with the works of (Chukwuma et al., 2013). The average pH of the controlled water samples was determined to be 6.8 which follow a similar trend in the works of (Chukwuma et al., 2013) and (Eruola et al., 2010), while the average pH value for the four roofing materials considered ranged between 6.9 and 7.5 which were found to be within the limits of (NSDWQ, 2007). This implies that the water samples were neither acidic nor basic nature. The average total solids for the samples collected over the three years period ranged between 38.9 and 47.8 mg/L which is an indication that the area where the samples were collected was residential area and the highest value of 47.8 mg/L was recorded in an area close to a community market which accounted for the high increase. This results were comparable to results obtained by (Chukwuma et al., 2013), but lower than (Eruola et al., 2010). The results were also below the recommended maximum permissible limit by (NSDWQ, 2007). It is important to note here that the zones for which the experiments were conducted varied from each other which may be a reflection of the change in climatic conditions observed in Nigeria. The average value for the total dissolved solids ranged between 52 and 115 mg/L which was recorded to below the recommended maximum value of 500 mg. Suspended solids for the control, sample C and sample A had zero value for the three year period of investigation and the other two samples had values of 2.8 and 3.1 mg/L. According to (Chukwuma et al., 2013), the palatability of water with a total dissolved solids (TDS) level of less than about 600 mg/L is generally considered to be good; drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/L. Thus for domestic use, rain water in this area can be said to be good as low level of pollution was observed. The average temperature for the various samples over the study period was collected at 23.2 ^{0}C. Though, no recommended value was provided for by (NSDWQ, 2007). The turbidity value ranged between 2 and 6.4 mg/L. Sample B which represented the old galvanized roofing sheet was observed to have the highest value due to the presence of suspended particulates. In most waters, turbidity is due to colloidal and extremely fine dispersions.

Electrical Conductivity (Ec) is related to the concentration of ionized substance in water. Ec for zinc coated roofing materials not older than six months had an average value of 367 µs/cm while that older than six months averaged 432 µs/cm. Those of aluminum roofing materials less than six months averaged 394 µs/cm while those more than six months averaged 478 µs/cm. This is a strong indication that no matter the age of these two roofing materials considered for this study, the Ec will be on a steady increase. These results were observed to be higher for zinc coated roofing materials when compared with the work of (Polkowska, 2014) who examined the effect of some type of roofing on pollutant content in roof runoff waters from building in selected districts of the city of Gdansk. There is a strong indication here that some level of soluble salts are released into the air from the environment which later dissolve into the rainwater. All the obtained average values were found to be below the NSDWQ, 2007 specification of 1000 µs/cm thus making the rainwater collected in this study area useable for domestic purposes.

Total alkalinity is the total concentration of bases in water expressed as parts per million (ppm) or milligrams per liter (mg/L) of calcium carbonate ($CaCO_3$). According to (Olaoye and Olaniyan, 2012), in natural waters, the alkalinity is related to the bi-carbonates HCO_3, carbonate CO and hydroxide OH concentration. The average value for alkalinity of the samples from new zinc roofing material was 48.7 mg/L that of the old zinc roofing material was 52 mg/L, the new aluminum roof averaged 27.1 mg/L while the old aluminum roof was 36 mg/L. All the values were found to be within the recommended standard value of (NSDWQ. 2007). Water with high total alkalinity is not always hard, since the carbonates can be brought into the water in the form of sodium or potassium carbonate. An important environmental aspect of alkalinity in natural water is the capacity to neutralize acidity originating from atmospheric decomposition. Although alkalinity has a little public health significance, highly alkaline waters are unpalatable and are not used for domestic water supply. The hardness of water is characterized by its ability to form lather with soap. Total hardness is defined as the sum of Ca and Mg concentrations expressed as calcium carbonate in mg/L or ppm. Total hardness (Ca and Mg) for the different types of roofing materials of various ages in the study area showed that the new zinc roofing material of ages less than six months had an average value of 55 mg/L while those older than six months had an average value of 39 mg/L. the new aluminum roofing material of ages less than six months had an average value of 93 mg/L while those older six months was 75 mg/L. It can also be observed from the results that the older the age of the two types of roofing material the less the Ca and Mg content of the rainwater. This may be linked to fact that most of the chemical reactions took place during the early age of the installation of the various roofing materials and also due to the fact that there are no industries within the immediate environment of the study area, thus the level of air pollution is reduced which also implies lower chemical reactions. From Table 2, it is observed that newly installed roofing materials of ages not more than six months had the highest level of Calcium and Magnesium content. Unlike the study carried out by (Eruola et al., 2010) which observed that asbestos roofing materials recorded the highest level of total hardness in Abeokuta.

The Chloride content for all the four sampled roofing materials were observed to be below the maximum permissible limit of 200 mg/L as recommended by (NSDWQ, 2007). The control which is the direct rain water had an average value of 6 mg/L. The zinc coated roofing material with ages less than six months had an average value of 4 mg/L while those older than six months had an average value 8 mg/L. for the aluminum roofing material which are less than six months old had an average value of 10 mg/L while those older than six months had an average value of 12 mg/L. From this results, it was observed that the Chloride content for the various roofing materials with respect to the varying ages were on the increase. This result was compared with the works of (Olaoye and Olaniyan, 2012) and was observed to be much higher which can be as a result of difference in location and proximity to industrial layouts.

Sulphate (SO_4^{2-}) is a major ion occurring in water, with its main source from the process of chemical weathering and dissolution of sulphur containing minerals, predominantly gypsum ($CaSO_{4.}2H_20$). Other natural sources are the oxidation of sulphides and elemental sulphur, and the decomposition of animal and plant residues (Magnus, 2011; Ochuko and Thaddeus, 2013; Amponsah et al., 2015). Sulphate values obtained for the control was 5 mg/L while the average obtained value for zinc coated roofing materials of less than six months was 0.9 mg/L and those more than six months was 29 mg/L. The average obtained value for aluminum of age less than six months was 26 mg/L while those more than six months was 4 mg/L. It was observed that the sulphate content increased with respect to age in the case of zinc coated roofing material while in the case of aluminum roofing material the sulphate content reduced drastically with respect to age of the material. The maximum permissible limit of 50 mg/L was recommended by (NSDWQ, 2007). The control sample had an average value of 1.98 mg/L while zinc coated roofing material whose ages were less than six months was 28 mg/L and those whose ages were more than six months had an average value of 24.1 mg/L. the average value obtained for aluminum roofing material with ages less than six months was 23.1 mg/L while those with ages more than six months is 3 mg/L. all the observed values were below the recommended standard (NSDWQ, 2007).

The presence of nitrate ions in unpolluted surface is due mainly to processes in the water body itself, such as nitrification. The nitrate content of drinking water is rising at an alarming rate in both developed and developing countries owing largely to lack of proper sewage treatment, and excessive fertilizer application. Nitrate in drinking water is a major health concern because of its toxicity, especially to young children (Nicholson et al., 2009). With the control experiment which is the directly collected rainwater, the potassium content averaged 2 mg/L. the zinc coated roofs which were less than six months of age had an average value of 2 mg/L while zinc coated roofs of more than six months but less than fifteen years gave an average value of 3 mg/L. The quantity of potassium for the zinc coated roof of ages for the rainwater collected over a long period of time were observed to be higher though the fraction is very much manageable. For aluminum roofs of ages less than six months had an average value of 2 mg/L while those of more than six months but less than fifteen years gave an average value of 3 mg/L. the quantity of potassium for the zinc coated roofing materials and those of the aluminum roofs of less than six months and those more than six months but less than fifteen years were observed to have the same value which can be linked to potassium content in the air. This is similar to the study carried out by (Dami et al., 2012) and (Mendez et al., 2010). Furthermore, Dami et al., 2012, stated that the presence of potassium in any form for domestic use is known to cause hypopotasaemia in human.

The iron content found in the controlled rainwater had an average sample of 0.1 mg/L. The zinc coated roofing materials of less than six months had an average value of 0.14 mg/L while those that were more than six months but less than 15 years had an average value of 0.21 mg/L. For aluminum coated roofing materials with ages less than six and those more than six months but less than 15 years had an average value of 0.02 mg/L respectively. According to the NSDWQ, 2007, specification for zinc is recommended as 3 mg/L. The entire samples considered for this study all fell within the recommended specification. The rainwater within the study area was observed to be adequate in concentration. This is in conformity with the works of (Olaoye and Olaniyan, 2012).

5. Conclusion

The results from the physiochemical analysis of water samples collected from galvanized rooftop and aluminum shows that the tested parameters were within the recommended specifications of (NSDWQ, 2007), thus the harvested rainwater can be used for domestic or agricultural purpose. However, the first flush from the rooftops cannot be used because of the level of accommodation of dirt and rust. It is safer to allow for the first flush from the rooftops in order to eliminate bacteriological contamination. Therefore, it is possible to harvest rainwater that could meet the NSDWQ guidelines as long as materials used to construct RWH systems are 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.

Acknowledgement

The authors are grateful for financial assistance received from the Nigerian government under the Tertiary Education Trust Fund (TET-FUND), for academic research and development.

References

Achadu, O.J, Ako, F.E. & Dalla, C.L. (2013). Quality Assessment of Stored Harvested Rainwater in Wukari, North-Eastern Nigeria: Impact of Storage Media. *IOSR Journal of Environmental Science, Toxicology and Food Technology,* 7(*5), 25-32*.

Adesiji, A.R. & Jimoh, O.D. **(**2012). Estimation of runoff from Chanchaga River Basin using Soil-Water Balance Approach. *Nig. J. Hyd. Sci., 1, 29 – 40*

Akintola, O.A. & Sangodoyin, A.Y. (2011). The Suitability of domestic roof harvested rainwater as source of irrigation water for homestead gardening. *Centre point Journal (Science Edition), 17, 61-69.*

Amponsah, N., Bakobie, N., Cobbina, S.J. & Duwiejuah, A.B. (2015). Assessment of Rainwater Quality in Ayanfuri, Ghana. *American Chemical Science Journal 6(3), 172-182.*

Aydin, N. Y. (2014). Scenario-Based Sustainability Assessment to Provide Interactive Decision Support for the Long-Term Transition of Urban Water Supply Systems. A Dissertation Submitted to Faculty of Civil Engineering, University of Kai serslautern.

Chukwuma, E.C, Ogbu, K.N. & Okonkwo, I.F, (2013). Quality Assessment of Direct Harvested Rainwater in Parts of Anam bra State, Nigeria. *International Journal of Agriculture and Biosciences 120-123*.

Cobbina, S.J, Michael, K, Salifu, L & Duwiejua, A.B. (2013). Rainwater Quality Assessment in the Tamale Municipality. *International Journal of Scientific & Technology Research, 2 (5), 1-.5*.

Dami A, Ayuba H.K. & Amukali O. (2012). Effects of Gas Flaring and Oil Spillage on Rainwater Collected for Drinking in Ok pai and Beneku, Delta State, Nigeria. *Global Journal of Hu man Social Science, Geography & Environmental geosci ences. 12(13), 1-6.*

Daum, P.H. Kleinman, L.I, Newman, L, Luke, W.T, Weinstein-Lloyd, J, Berkowitz, C.M. & Busness, K.M. (1996). Chemi cal and physical properties of plumes of anthropogenic pollu tants transported over the North Atlantic during the North At lantic Regional Experiment. *Journal of Geophysical Research, 101, D22, 29,029-29,042.*

Despins C, Farahbakhsh K. & Leidl C, (2009). Assessment of Rain water quality from rainwater harvesting systems in Ontario, Canada. Journal of Water Supply: *Research and Technology- AQUA* 58 (2), 117-134.

El Atta, H. A. & Aref, I. (2010). Effect of terracing on rainwater harvesting and growth of *Juniperus procera* Hochst. ex End licher. *Int. J. Environ. Sci. Tech., 7 (1), 59-66.*

Eletta, O.A.A. & Oyeyipo, J.O. (2008). Rain Water Harvesting: Ef- fect of Age of Roof on Water Quality. *International Journal of Applied Chemistry, 4(2), 157-162.*

Eruola, A.O, Ufoegbune, G.C, Eruola, A.O, Adeofun, C.O, Idowu, O.A. & Sowunmi, A. (2010). Qualitative and Quantitative Assessment of Rainwater Harvesting Rooftop Catchment: Case Study of Oke-lantoro Community in Abeokuta, South west Nigeria. *European Water 32, 47-56*

Farreny, R, Morales-Pinzon, T, Guisasola, A, Taya, C, Rieradevall, J. & Gabarrell, X (2011). Roof selection for rainwater har- vesting: Quantity and quality assessments in Spain. *Water Re search, 45,(10), 3245–3254.*

Ishaku, H.T, Majid, M.R.& Johar, F. (2012). Rainwater Harvesting: An Alternative to Safe Water Supply in Nigerian Rural Communities. *Water Resources Management, 26, (5), 295- 305.*

Kahinda, J.M, Taigbenu, A.E. & Boroto, J.R (2007). Domestic rain water harvesting to improve water supply in rural South Af rica. *Physics and Chemistry of the Earth, Parts A/B/C, 32, (15– 18), 1050–1057.* doi:10.1016/j.pce.2007.07.007.

Kumar, A. (2015). Civil Society Stewardship towards Sustainable Water Use in Agriculture. India Water Foundation, :http://in diawaterfoundation.org/ViewLetter.aspx?CId=432

Kus, B., Kandasamy, J., Vigneswaran, S. & Shon, H. K. (2011): Water Quality in Rainwater Tanks in rural and Metropolitan Areas of New South Wales, Australia. *Journal of Water Sus tainability*, 1, *(1), 33–43.*

Lee, J.Y, Bak, G. & Han, M. (2012): Quality of roof-harvested rain water-Comparison of different roofing materials. *Environ mental Pollution*, *162, 422–429.*

Li, Z., Boyle, F. & Reynolds, A. (2010): Rainwater harvesting and greywater treatment systems for domestic application in Ireland. *Desalination,* 260, (3), 1–8.

Lye, D.J (2009). Rooftop runoff as a source of contamination: A re view. *Science of The Total Environment, 407, (21), 5429– 5434.*

Magnus, OO. (2011). Assessment of Rain Water Harvesting Facili ties in Esanland of Edo State, *Nigeria. J. Hum Ecol.,* 34(1): 7-16

Maliszewska-Kordybach, B. (1999): Sources, Concentrations, Fate and Effects of Polycyclic Aromatic Hydrocarbons (PAHs) in the Environment. Part A: PAHs in Air: A Review. Polish Jour nal of Environmental Studies 8: (3), 131-136.

Mendez, B.C, Brigit, R.A., Kerry, K., Michael, E. B. & Kirisits, M.(2010). Effect of Roof Material on Water Quality for Rainwa ter Harvesting Systems. Texas water Development Board Re port, Capitol Station, Austin, Texas 78711-3231, January 2010 Report, The University of Texas at Austin.

Moglia, M. (2010): Water management in the developing town: a complex systems perspective. A Thesis Submitted for the Degree of Doctor of Philosophy at the Australian National University.

Mostafa, M.G. & Shafiuzzaman, SM (2008). Potential use of mon soon rainwater for drinking purpose in Bangladesh, Proceed ings from the IWA World Water Congress and Exhibition 2008, Vienna, Austria.

Musa J. J. & Ahanonu, J. J. (2013). Quality Assessment of Shal low Groundwater in Some Selected Agrarian Communities in Patigi Local Government Area, Nigeria. International Journal of Basic and Applied Science, *1, (3), 548-563.*

Musa, J. J., Adejumo, B. A. & Fumen, G. A. (2013): Comparative Analysis of Water Samples from three different sources (A Case Study of Bosso, Minna Niger State). *IOSR* Journal of Environmental Science, Toxicology and Food Technology, *4, (5), 06-10.*

Musa, J.J, Adewumi, J.K. & Ohu, J. (2012). Comparing Developed Manning Coefficients for some selected soils Gidan Kwano with Exiting Values. Electronic *Journal of Geotechnical En gineering (EJGE),* 17: 2999-3008.

Nicholson, N, Clark, S.E, Long, B.V, Spicher, J. & Steele, K.A. (2009). Rainwater harvesting for non-potable use in gardens: a comparison of runoff water quality from green vs. traditional roofs. In: Proceedings of World Environmental and Water Resources Congress 2009 - Great Rivers Kansas City, Missouri.

NSDQW- Nigerian Standard for Drinking Water Quality, (2007). Nigerian Industrial Standard, NIS 554 with Standard Organi zation of Nigeria – SON

Ochuko, U. & Thaddeus, O. (2013). A Comparative Assessment of the Quality of Harvested Rainwater, Underground Water and Surface Water for Domestic Purposes in Ughelli, Southern Ni geria. *Journal of Environment and Earth Science. 3, (12), 9 -13*

Olaniyi, O.A, Babatola, E.B. & Ayoade, O.J. (2013). Demand for Potable Water in Ilaje Local Government Area Ondo State. Nigeria. *Journal of Environment and Earth Science 3, (1), 72- 79.*

Olaoye, R.A. & Olaniyan, O.S. (2012). Quality of Rainwater from Different Roof Material. *International Journal of Engineering and Technology, 2, (8):1413- 1421.*

Polkowska Ż. (2014): Examining the Effect of the Type of Roofing on Pollutant Content in Roof Runoff Waters from Buildings in Selected Districts of the City of Gdańsk. *Polish Journal of Environmental Studies 13, (2), 191-201.*

Radaideh, J., Al-Zboon, K., Al-Harahsheh, A. & Al-Adamat, R. (2009). Quality Assessment of Harvested Rainwater for Do mestic Uses. *Jordan Journal of Earth and Environmental Sci ences*, 2(1):26 -31.

Saha, R, Ghosh, P.K, Mishra, V.K. & Bujarbaruah, K.M. (2007). Low- cost micro-rainwater harvesting technology (Jalkund) for new livelihood of rural hill farmers. *Current Science, 92, (9), 1258- 1265*

Samuel, MP, Mathew, AC (2008). Rejuvenation of Water Bodies by Adopting Rainwater Harvesting and Groundwater Recharging Practices in Catchment Area- A Case Study. Proceedings of Taal2007: The 12th World Lake Conference: 766-776

Tam, VWY, Tam, L. & Zeng, SX. (2010). Cost effectiveness and tradeoff on the use of rainwater tank: An empirical study in Australian residential decision-making. *Resources, Conservation and Recycling, 4, (3), 178–186.*

Thomas, T. (1998). Domestic water supply using rainwater harvest ing. *Building Research and Information, 26, (2), 94-101.*

WHO (2010). World Water Day, water for Health, WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland.

Xiaoyan, L., Ruiling, Z., Jiadong, G. & Zhongkui, X. (2002): Ef fects of Rainwater Harvesting on the Regional Development and Environmental Conservation in the Semiarid Loess Re gion of Northwest China. 12th ISCO Conference, Beijing. *482-486*

Zhu, K., Zhang, L., Hart, W., Liu, M. & Chen, H. (2004). Quality issues in harvested rainwater in arid and semi-arid Loess Plat eau of northern China. *Journal of Arid Environments, 57, (4): 487–505.* doi:10.1016/S0140-1963(03)00118-6.

Table 2: Average values of the Physical and chemical Analysis of rain water samples

S/N	Parameters	Control	Sample A (new zinc)	Sample B (old zinc)	Sample C (new aluminium)	Sample D (old aluminium)	NSWDQ
1	Colour	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless
2	Odour	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Odourless
3	Taste	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Tasteless
4	Electrical conductivity (us/cm)	232	367	432	394	478	1000 μs max
5	pH	6.8	6.9	7.3	7.1	7.5	6.5 -8.5
6	Total Solids (mg/L)	38.9	42.7	47.8	43.2	41.6	500mg max
7	Total dissolved solid (mg/L)	74	88	52	115	68	500mg max
8	Suspended solids (mg/L)	0	0	2.8	0	3.1	-
9	Temperature in lab. (^{0}C)	23.2	23.2	23.2	23.2	23.2	-
10	Turbidity (NTU)	2	2.1	6.7	1.8	2.4	5mg max
11	Total Alkalinity (mg/L)	16.5	48.7	52	27.1	36	100mg max
12	Total hardness (mg/L)	64	55	39	93	75	500mg max
13	Chloride (mg/L)	6	4	8	10	12	200mg max
14	Sulphate (mg/L)	5	0.9	29	26	4	250mg max
15	Nitrate (mg/L)		0	0	0	0	0.02mg max
16	Nitrate (mg/L)	1.98	28	24.1	23.1	18	50mg max
17	Potassium (mg/L)	2	2	3	2	3	10mg max
18	Calcium (mg/L)	0	0	0	0	0	75mg max
19	Magnesium (mg/L)	0	0	0	0	0	30mg max
20	Iron	0.1	0.14	0.21	0.02	0.02	0.3mg max
21	Zinc (mg/L)	0	1	2	0	0	3mg max