Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Quality of Rainwater Harvested Around Owerri Area of Imo State, Nigeria

Donatus Okwudiri Igbojionu[1] Oluyemi Akande[2] Juliet Nnennaya Igbojionu[3] Femi Durumba[4]Margret C. Onwujiariri[5]

[1]*Department of Soil and Water Engineering Technology, Federal College of Land Resources Technology, Owerri, Nigeria*

[2,4&5]*Department of Environmental Management Technology, Federal College of Land Resources Technology., Owerri, Nigeria.*

[3]*Department of Soil Science Technology, Federal College of Land Resources Technology, Owerri, Nigeria.*

Corresponding author's email: igbojionudonatus@gmail.com

--************************--

Abstract:

The study was carried out to assess the quality of rainwater harvested from corrugated iron roofs in four locations around Owerri area namely Orji, Douglas road, New Owerri and Eziobodo between the months of June and October, 2016. The water samples collected were taken to the laboratory and analyzed as recommended by Nigerian Standard for Drinking Water Quality (NSDQW) and World Health Organization (WHO) standard for Drinking Water Quality.Chemical parameters such as Nitrate, Iron, Calcium, Sodium and Sulphate conformed to the recommended standard value. Results of elemental analysis showed that Lead and Mercury concentrations in the rainwater in all the sampled locations of 0.033 mg/l, 0.139mg/l, 0.173 mg/l, 0.133mg/l, and0.172 mg/l, 0.21 mg/l, 0.260 mg/l, 0.198 mg/l respectively exceeded the recommended threshold for drinking water. Magnesium concentration also exceeded the recommended permissible limit with average values that varied from 3.0 mg/l to 13 mg/l. Total Coliform was only detected in rainwater samples collected in two of the sampled locations but with concentrations that conformed to the recommended standard value. There was no presence of pathogenic bacteria in all the water samples collected. The rainwater in these locations is not fit for human consumption considering the high concentration of heavy metals.

Keywords: **Water quality, rainwater, assessment, roof catchment**

--************************--

I. INTRODUCTION

Water harvesting is an umbrella term describing a range of techniques for collecting, concentrating and conserving water from various sources for various purposes. [1] define rainwater harvesting as the art and science of collecting water where it falls while [2] refer to it as the principle of using precipitation from small catchment. Rainwater harvesting as a source of water supply for various purposes has been practiced in many countries of the world for millennia [1], [3], [4], [5]. Extensive rainwater harvesting systems existed 4,000 years ago in the Negev Desert and in the ancient Roman Empire, residences were built with individual cisterns and courtyards to capture rainwater to augment other water sources. In African rainwater harvesting has been practiced for at least 2000 years and in Asia for 9000 years [6]. Today, it is estimated that there are more than 2 million water systems supplying household water needs worldwide. Of this number, more than 250,000 systems are located in the United States of America.

As a result of population growth and urban expansion, the municipalities of cities in developing countries of Africa, Asia and Latin America are struggling hard to provide their citizens with drinking water of acceptable quality at reasonable cost. In many cases, whether in dry or humid regions, the available water resources are either insufficient to meet the escalating demands or of low quality to make them acceptable for human useswithout expensive treatment. In Imo state, Nigeria for instance, most of the rural and semi-urban communities are not connected to the public water supply systems. Provision of water for various uses in rural and urban areas is one of the greatest challenges in Nigeria today as more than 52 % of the people lack access to improved drinking water supply[7], [8], [9].

In order to meet our future water needs, new solutions are needed that are both economic and environmental friendly. Rainwater harvesting through a collection system exemplifies simple application of sustainable design. Such a system is independent of any centralized water system and helps to foster appreciation for water as an essential and precious resource. The roof catchment is the most basic requirement of a rooftop rainwater harvesting system [10]. The quality of harvested water depends on the type and condition of roofing material, storage tanksand prevailing human activities where the system is located[11], [12]. The quality of drinking water is a powerful environmental determinant of health. Water is a commodity vital to life, but it can transmit diseases. The most predominant water borne diseases like diarrhea/ dysentery has an estimated annual incidence of 4.6 billion episodes and causes 2.2 million deaths every year[13]. Rain can provide clean, safe and reliable water so long as the collection systems are properly built and maintained and water treated appropriately based on the intended use. Evaluation of water quality of harvested rainwater as an augmenting water source in Owerri and its environs is essential to ascertain its suitability for human consumption and other uses.

II. MATERIALS AND METHODS

A. Study area.

The study area Owerri is located between latitudes 5^{o}25’ and 5^{o}45’N and longitudes 6^{o}58’and 7^{o}10’ E. It covers an area of about 740 km^{2}and has a population of about, 400,000 [14]. The climate is characterized by two major seasons: a rainy season and a dry season. Most of the mean annual rainfall estimated at 2152 mm [15] occurs during the rainy season, April to October. The rainy season is usually associated with moisture – laden maritime southwest trade winds from the Atlantic Ocean. According to 20 years rainfall record, the average number of rainy days is estimated at 140 [16].The temperature ranges from 23 to 26^{o}C while relative humidity ranges from 70 to 80 %.

There are four sources of water to the inhabitants of the study area. They are the public water systems, the Nwaorie Stream, the Otamiri River and boreholes. Of these sources of water, the public water supply systems are meant to be the major water supply source to the area and its environs but are obsolete and can no longer fulfil this function. Urbanization and industrialization through effluent discharges into the surface water bodies have rendered them unsuitable for domestic uses. The boreholes are not affordable source of water especially to the poor. The owners of these boreholes sell water from them to the public at exorbitant rates.

B.Rainwater Sampling and Analysis

Rainwater samples were collected on an event basis from corrugated iron roofs of four households in each of the selected areas (Douglas road, Orji, Imo housing and Eziobodo). Sterilized stainless steel basins were placed on a platform 1 m above ground level to collect rainwater after the first flush. The collected rainwater was then transferred into sterilized 2 l plastic bottles and transported immediately in black plastic bags packed with ice to the laboratory for chemical and microbial analysis within 16 hours of collection using standard procedure.

III. RESULTS AND DISCUSSION

A. Results from chemical analysis

1) pH value

The mean values of rainwater samples collected from iron roofs in Orji, Douglas road, New Owerri and Eziobodo are 7.69, 7.8, 7.96 and 8.88 respectively. The pH values fell within the NSDQW and WHO maximum permissible limit for drinking water of 6.5 to 8.5 except that recorded for Eziobodo. This could be attributed to the occurrence of a Calcium rich soil and its deposition by wind on the roof surfaces as dust. Fig. 1 shows the variation of pH in rainwater in the sampled areas with WHO standard.

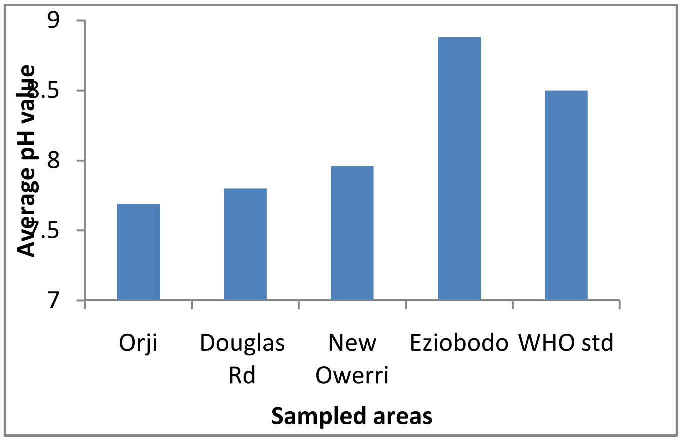

Fig. 1Average values of pH in rainwater in the sampled areas.

2) Zinc and Lead

The mean values of Zinc concentration in rainwater samples harvested in Orji, Douglas road, New Owerri and Eziobodo were 0.072 mg/l, 0.096 mg/l, 6.79 mg/l and 3.161 mg/l respectively. Lead had concentration values of 0.033mg/l, 0.139 mg/l, 0.193 mg/l and 0.133 mg/l in the rainwater harvested in Orji, Douglas road, New Owerri and Eziobodo respectively. Zinc concentration levels in the rainwater samples conformed to NSDWQ and WHO permissible limits of3.0 to 5.0 mg/l except for New Owerri.This could be attributed to the intensity of weathering of the corrugated iron roofs induced by acid rain. The ages of the roofs ranged between 2 and 6 years which suggest that the weathering process has not stabilized. The lead concentration levels exceeded the permissible limit of 0.01 mg/l recommended by NSDWQ and WHO for drinking water. Figure 2 shows variation of Zinc and Lead concentrations in rainwater in the sampled areas with WHO standard.

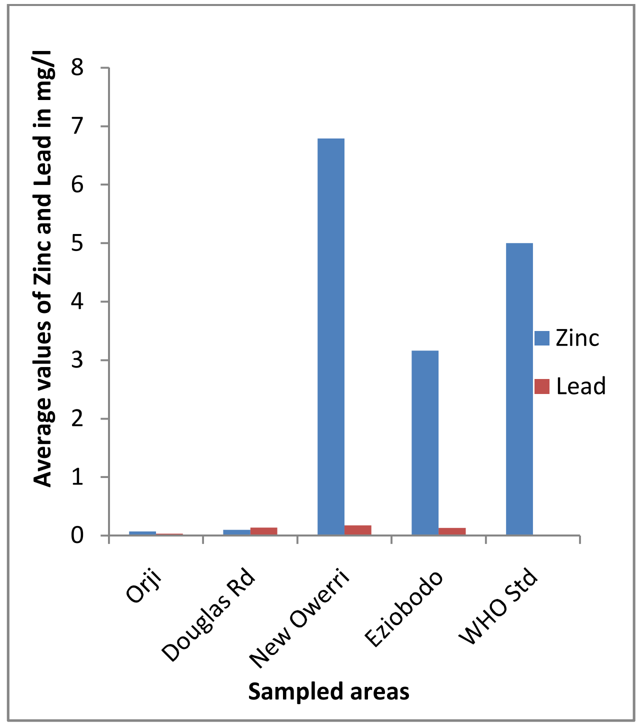

Fig. 2 Variation of Zinc and Lead concentrations in rainwater in samples areas with WHO (2010) standard.

3) Mercury and Nitrate

The mean values of Mercury in the water samples were 0.172 mg/l, 0.211 mg/l, 0.260 mg/l and 0.193 mg/l for Orji, Douglas road, New Owerri and Eziobodo respectively. These values did not conform to [13]and [17]standard of 0.001 mg/l.

The mean values recorded for Orji, Douglas road, New Owerri and Eziobodo were 0.240 mg/l, 0.248 mg/l, 0.382 mg/l and 0.430 mg/l respectively and which fell below NSDWQ and WHO

standard of 50 mg/l. Figure 3 shows variation of Mercury and Nitrate concentrations in rainwater in the sampled areas with WHO standard.

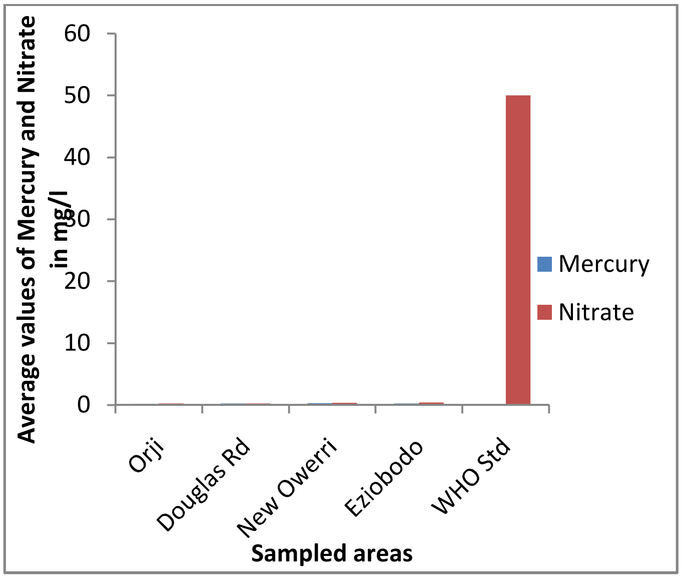

Fig. 3 Variation of Mercury and Nitrate concentrations in rainwater in the sampled areas with WHO (2010) standard.

4) Iron and Calcium

The mean values of Iron in rainwater samples collected in Orji, Douglas road, New Owerriand Eziobodo were 0.052 mg/l, 0.010 mg/l, 0.033 mg/l and 0.008 mg/l respectively while for Calcium mean values of 6.0 mg/l, 6.0 mg/l, 14.0 mg/l and 26 mg/l were obtained for Orji, Douglas road, New Owerri and Eziobodo respectively. Iron and Calcium concentration levels were below NSDWQ and WHO permissible limits of 0.3 mg/l and 100 to 300 mg/l respectively. High level of calcium obtained in Eziobodo could be attributed to the geologic formation which is dominated by limestone. Figure 4 shows variation of Iron and Calcium concentrations in rainwater in the sampled areas with WHO standard.

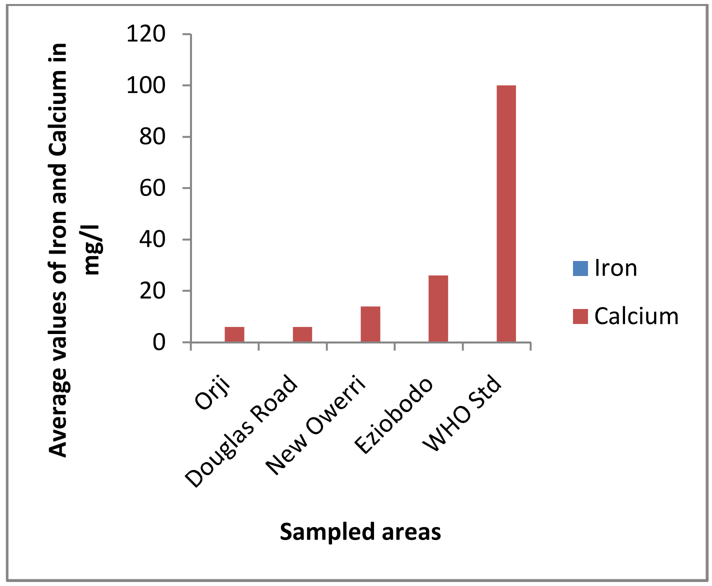

Fig. 4 Variation of concentrations of Iron and Calcium in rainwater in sampled areas with WHO standard.

5) Sodium and Magnesium

Mean concentration levels of Sodium in the water samples were 0.84 mg/l, 0.75 mg/l, 2.47 mg/l and 1.83 mg/l for Orji, Douglas road, New Owerri and Eziobodo respectively while Magnesium had mean values of 3.0 mg/l, 4.0 mg/l, 13 mg/l and 5.0 mg/l in Orji, Douglas road, New Owerri and Eziobodo respectively. The mean values of Sodium in the rainwater samples for all the selected locations were below NSDWQ permissible standard of 200 mg/l for drinking water. However, mean values of Magnesium in these rainwater samples showed marked deviation from NSDWQ and WHO permissible limits for potable water indicating the dust that get deposited on the roofs by the action of wind is rich in Magnesium. Fig. 5 shows variation of Sodium and Magnesium concentrations in rainwater in the sampled areas with WHO standard.

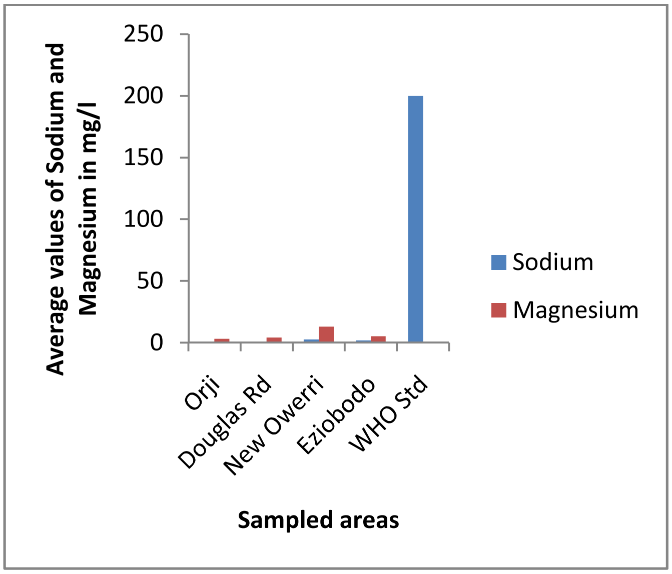

Fig. 5 Variation of concentrations ofSodium and Magnesium in rainwater in sampled areas with WHO standard.

6) Sulphate

Mean values of sulphate concentration in rainwater samples were 9.0 mg/l, 10.0 mg/l, 27.0 mg/l and 11.0 mg/l for Orji, Douglas road, New Owerri and Eziobodo respectively. These values conform to NSDWQ standard for drinking water of 100.0 mg/l.Figure 6 shows variation of Sulphate concentration in rainwater in the sampled areas with WHO standard.

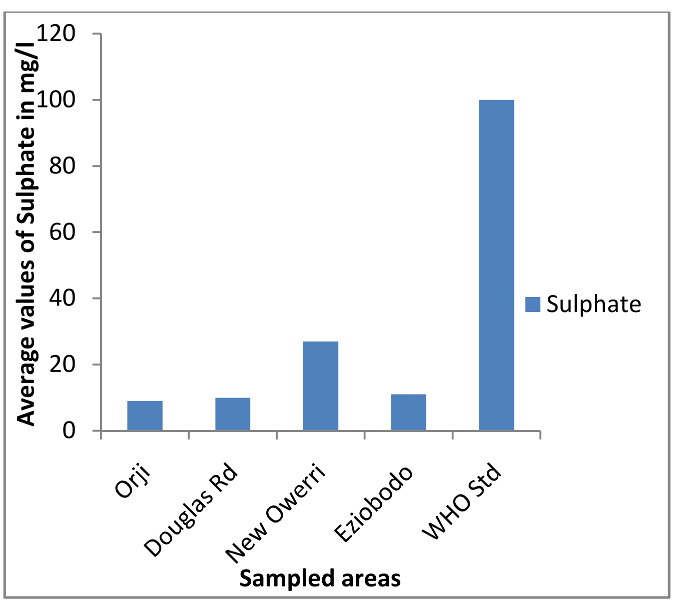

Fig.6 Variation of Sulphate concentration in rainwater in sampled areas with WHO standard

B. Results from microbiological analysis

1) Total Coliform and Faecal Coliform

Mean values of Total Coliform count in rainwater samples in Orji, Douglas, New Owerri and Eziobodo were 2.0 cfu, 2 cfu, 0.0 cfu and 0.0 cfu respectively. The above mean values fell within the NSDWQ acceptable limits of 0 – 10 cfu.

The E. coli count in all of the water samples was 0.0 cfu which showed that they were free from human waste contamination. This suggests that the coliform group of organisms found in Orji and Douglas road rainwater samples were not pathogenic.Figure 7 shows variation of microbial parameters in rainwater in the sampled areas with WHO standards**.**

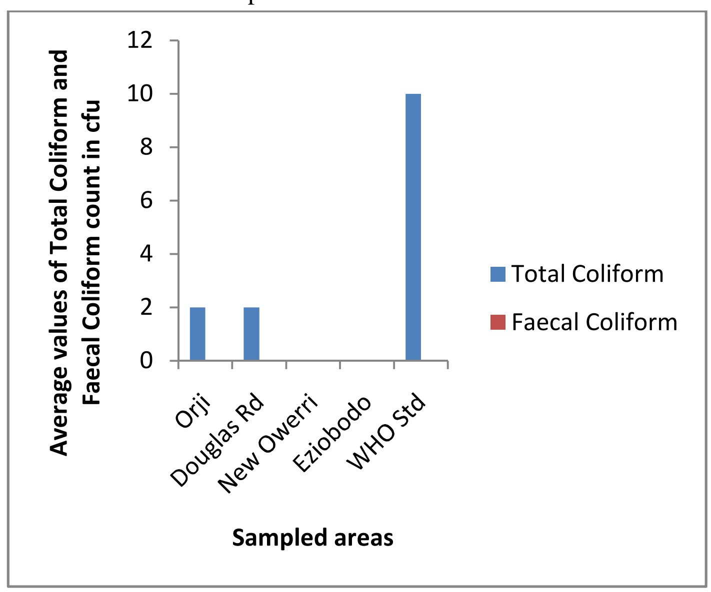

Fig. 7 Variation of microbial parameters in rainwater in sampled areas with WHO standard

IV. CONCLUSION

The results show that the concentrations of most of the chemical parameters analysed conformed to the prescribed drinking water quality standard of the Nigeria Standard for Drinking Water Quality (NSDWQ) and WHO standard for drinking water quality.

Consequently, rainwater in the sampled areas can be considered a suitable drinking water source. This may have accounted for its general acceptance by the inhabitants who use it for diverse purposes.

Elemental analysis, however, showed that lead and mercury concentrations in the rainwater exceeded recommended threshold. This can be attributed to industrial activities and the prevailing high traffic density and suggests that long consumption of rainwater in these areas may pose serious health risk to consumers.

There was no presence of pathogenic micro-organisms in all rainwater samples especially E. coli. However, this does not guarantee the potability of rainwater in these areas. Therefore, precaution is strongly advised during handling to avoid contamination as a result of human contact.

REFERENCES

[3] Agarwal A and Narain (1997): Rise, fall, potential of India's traditional water harvesting systems. Centre for Science and Environment, New Delhi.

[4] Pacey A.and Cullis A. (1986): Rainwater harvesting: The collection of rainfall and run-off in rural areas. Intermediate Technology Publications Ltd, London.

[5] Mayo A. W. and Mashauri D. A.(1991): Rainwater harvesting for domestic use in Tanzania. A case of study of Dar es Salam staff houses, Water International, 16(1); 2-8.

[6] Peter C (2007): An investigation into the potential to reduce the cost of constructed rainwater harvesting tanks in Uganda, School of Applied Sciences, Department of National Resources, Cranfield University, UK.

[7] Vikaskumar G. S., Dunstan R. H., Geary P. M., Coombes P., Roberts T.K. and Rothkirch T. (2007): Comparisons of water quality parameters from diverse catchments during dry periods and following rain events. Water Research, 41 (16): 3655-3666.

[8] Gould J. A. (1993): A review of the developments, current status and future potential of rainwater catchment systems for household supply in
[1] Monanu S and Inyang F. (1975): Climate Regimes. In: Nigeria in Map (ed. by G.F.K. Ofomata). Ethiope, Publishing House, Benin, pp 27-29

[2] Igbojionu D. O. (2000): Augmenting rural water supply by rooftop rainwater harvesting: Case study of Egbeada, Imo State, Nigeria. MSc thesis, Faculty of Civil Engineering and Surveying, University of Karlsruhe,Germany

Africa. Proceedings of 6th International Conference on Rainwater Catchment Systems, Nairobi, Kenya.

[9] Lekwot V. E., Ikomomi S, Ifeanyi E. and Onyemalukwe O. (2012): Evaluating the potential of rainwater harvesting as a supplementary source of water supply in Kanai (Mali) district of Zango – Kataf local government area of Kaduna State, Nigeria. Global Adv. Res. J. Environ. Sci. Toxicol. 1930: 38-45

[10] Orebiyi E. O., Awomeso J. A., Idowu O. A, Martins O., Oguntoke O. and Taiwo A. M (2010): Assessment of pollution hazards of shallow well water in Abeokuta and environs, South Western Nigeria. Ame. J. Environ,. Sci. 6:50-56.

[11] Tobin E.A., Ediagbonya T. F., Ehidiamen G. and Asogun D. A. (2013): Assessment of rainwater harvesting systems in a rural community of Edo State, Nigeria. J. of Public Health and Epidemiology, Vol. 5(12):479-487.

[12] Ntale H. (1996): The potentials of rainwater harvesting in the suburbs of Uganda. Proceedings of IAHR African Division, 5-7th August, 1996, pp1-10.

[13] Ariyanda T (1999): Comparative review of drinking water quality from different rainwater harvesting systems in Sri Lanka. Proceedings of the 9thInternational rainwater catchment systems conference on Rainwater Catchment: An answer to the water scarcity of the next millennium. Petrolina, Brazil, July 1999. Paper72.

[14] OlaoyeR. A. and Olaniyan O. S. (2012): Quality of rainwater from different roof materials. International Journal of Engineering and Technology, Vol. 2(8): 1413-1421

[15] WHO (2010): World Water Day, Water for Health. WHO press, World Health Organization, 20 Avenue Appia1211, Geneva 27, Switzerland.

[16] Uma K. O. (1984): Water resources potentials of Owerri and its environs, Imo State, Nigeria. J. Mining Geol. 22(1-2): 57-64

[17] NSDQW- Nigerian Standard for Drinking Water Quality (2007): Nigerian Industrial Standard, NIS 554. Approved by Standard Organization of Nigeria Governing Council, ICS 13060, 20: 15- 19.

.

.

.

