



## Gross Effect of Beta Radioactivity Concentration in Groundwater at Kakuri, Kaduna South Local Government Kaduna, Nigeria

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### **Authors' contributions**

*This work was carried out in collaboration between all authors. Author TOA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors EOA and HOO managed the analyses of the study. Author TOA managed the literature searches. All authors read and approved the final manuscript.*

### **Article Information**

DOI: 10.9734/AJEE/2017/38474

#### Editor(s):

- (1) Angelo Paone, Biologia, Scienze della Terra, Istituto Tognazzi, Italy.  
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Complete Peer review History: <http://www.sciencedomain.org/review-history/22632>

**Original Research Article**

**Received 28<sup>th</sup> November 2017**  
**Accepted 3<sup>rd</sup> January 2018**  
**Published 8<sup>th</sup> January 2018**

### **ABSTRACT**

Water pollution is probably one of the most important threat because of its health hazards. Water pollution is the contamination of the water bodies such as lakes, rivers, ocean and underground water by human or natural activities that constitute a great deal of danger to both plants, animals and human being. Petroleum and refinery wastes, application of nitrates and phosphates fertilizers, mining wastes, radioactive substances, toxic chemicals and wrongful disposal of sewage are the main causes of water pollutions in Nigeria. The aim of this study was to determine the level of beta radioactivity in underground water at Kakuri Kaduna South Local Government Area Council of Kaduna state, Nigeria, located within latitude  $10^{\circ}28'10''$  and longitude  $7^{\circ}25'10''$  covering  $59 \text{ km}^2$  with population of 402,390 according to the census report conducted in 2006. Ten water samples including five hand-dug wells and five boreholes were sampled and analyzed using the portable single channel Gas free MPC2000b-DP detector. The range of beta activity varied from  $0.200 \pm 0.041 \text{ Bq/L}$  to  $1.530 \pm 0.141 \text{ Bq/L}$  with a mean value of  $0.613 \pm 0.104 \text{ Bq/L}$  as shown from the result. This result

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showed that the beta activity was below the recommended value set by world health organization (WHO) which was 1.0 Bq/L per year. But transformer borehole had higher value of 1.530 Bq/L which posed threat to the human health. Therefore, if the water from the remaining samples point is consumed, it posed no threat to the health of the people around the area.

*Keywords: Beta; borehole; Kaduna; Kakuri; hand dug well; radioactivity.*

## 1. INTRODUCTION

Most of the sources of water supply in Nigeria are upland surface water or groundwater from boreholes and hand dug wells. Groundwater is the water located in soil pores and in the fractures of rock formation [1,2]. A unit of rock or an unconsolidated deposit is called an aquifer; when it can yield a usable quantity of water. Groundwater is recharged naturally by the surface water [3,4]. This water might contain radionuclide which may be natural or artificial. Naturally occurring radioactive materials (NORM) are found almost everywhere and are inherent in many geologic materials; consequently it is encountered during geological related activities [5]. The earth's crust contain naturally occurring radioactive materials (terrestrial radioactivity), and of most concern remained in uranium series, thorium series and their progeny (radon and thoron) which increases with depth of the ground water [5,6]. Because of this, drinking water from deep wells and boreholes is likely to contain a higher concentration of radioactive elements than surface water [7]. Spring or flowing water, passes through rocks that may contain radioactive materials and it could be transported into wells, boreholes and taps water through burst pipes. Important radionuclide in drinking water is tritium, potassium-40, radium and radon, which are alpha, beta and gamma emitters [8]. The beta activities measured could be from one of the following major sources; anthropogenic factor (i.e. the atmospheric fall-out), deposition of radionuclide into the soil as a particle or dissolved nutrient and primordial sources as a result of rocks/hills in an environment. Radionuclide may be deposited into the soil either as particles or dissolved into soil water through the application of fertilizers and composite manure [9,10]. These radionuclide, when absorbed by the root as nutrient will be translocated into various parts of boreholes and wells [11]. The transfer of radionuclide from soil to water channels depends on the types of soil and water samples. Mobility of the radionuclide is another important factor responsible for the concentration [6,12,13]. The atmospheric fall-out

sometimes contributed immensely to the water concentration measured. This normally occurred as a result of nuclear disaster like disposal of radioactive waste material into the river. Radionuclide particles suspended in air could be deposited on the soil surface which later dissolved and the level of contamination therefore depends on the surface area of the water [14,15]. The aim of this work is to analyze the concentration of beta particles in water samples using the proportional counter to determine the beta activity levels in hand dug wells and boreholes in Kakuri, Kaduna south Local Government Kaduna, Nigeria.

## 2. MATERIALS AND METHODS

Kaduna South is one of the Local Government Councils in Kaduna State, Nigeria, Kaduna is located between latitude  $10^{\circ}20'N$  and  $10^{\circ}33'N$  and longitude  $7^{\circ}45'E$  and  $7^{\circ}75'E$ , and has an area of  $46.053 \text{ km}^2$  and a population of 6,066,562 by the 2006 census. The materials that were used for this research work are: Syringe, Planchette, Acetone, Cotton wool, Weighing balance, Infrared radiator, MPC 2000 B-DP (Dual Phosphor), Vinyl acetate, Concentrated nitric acid commonly used as trioxonitrate(v) acid, Spatula, Ceramic dish. The detector used is protean instrument corporation (PIC) MPC 2000 DP (dual phosphor) and the calibration sources used was: Sr-90 a beta source, the beta detection limit is 1.75 cpm. The method applied to this sampling is the stratified random sampling technique, the map is grid into five locations, two samples were obtained from each location: one from hand dug well and one borehole source which gives a total of ten samples, in kakuri area in Kaduna south of Kaduna state, these locations includes: samara road, Faskere Street, Zango Street, Galadimawa Street and transformer junction. The sampling procedure is in accordance with international standard organization (ISO-5667-3). At every point of sample collection the container is first rinsed twice before the water is put in the plastic container and concentrated nitric acid commonly used as trioxonitrate (v) acid is added (10 ml/2

litres). The purpose for this addition is, to prevent microbial activities lower the pH of the water, prevent absorption and precipitation of the sample by container walls. Evaporation was done using hot plates without stirring when water samples were transferred to 100 ml beaker and it took an average of 24 hrs to complete the evaporation of 1 litre of the water sample. When the sample is almost dried up (about 50 ml), It then transferred to the ceramic dish (which is sterilized to avoid cross contamination) and the dish placed under an infrared radiator at about 65°C until it completely dried and weighed to obtain the weight of the residue. Spatula was used to transfer 0.077 g of the residue into a sterilized planchette and then weighed. To obtain a uniform surface area of the sample for effective detection of the activities of the samples vinyl acetate added in order to bind the particles together and remove any moisture content, residue most then uniformly spread on the planchette. To avoid contamination of any form sterilizations were done using acetone.

## 2.1 Gross Beta Counting

The high voltage for gross beta counting was set at 1700 volts and sample were counted for 3 cycles of 3600 sec per cycle in beta only mode. The count rate and the activity were calculated using the formula [16].

$$\text{Count Rate } (\beta) = \frac{\text{Raw } (\beta) \text{ Count} \times 60}{\text{Count Time}} \quad (1)$$

$$\text{Activity } (\beta) = \frac{\text{Rate } (\beta) - \text{background count } (\beta)}{\text{SE} \times \text{CE} \times \text{V}} \quad (2)$$

Where: SE = Sample Efficiency; CE = Chanel Efficiency; V = Volume of Water Sample

## 2.2 Beta Activity

The beta activity is expressed as activity concentration C in Becquerel per liter (Bq/L). The activity concentration was calculated using the formula [17].

The sample location cut across 5 places in kakuri an area in Kaduna south Kaduna state, these locations includes samara road, Faskere Street, Zango Street, Galadimawa Street and transformer junction. From these places a total of 10 samples were collected i.e. 5 samples of hand dug well water and 5 samples of borehole water. The method applied to this sampling is the

stratified random sampling technique. The map is grid into five (5) locations, two samples were obtained from each location: one from hand dug well source and the other from boreholes source which gives a total of ten (10) samples. The sampling procedure is in accordance with international standard organization (ISO-5667-3). At every point of sample collection the container is first rinsed twice before the water is put in the plastic container and concentrated trioxonitrate (v) acid (nitric acid) is added (10 ml/2 litres). The reason for this addition is for:

- To lower the pH of the water to prevent microbial activities
- To prevent precipitation and absorption of the sample by container walls.

The water samples were transferred to 100 ml beaker and evaporation was done using hot plates without stirring. It took an average of 24 hrs to complete the evaporation of 1 litre of the water sample. When the sample is almost dried up to 50 ml it is then transferred to the ceramic dish which is sterilized to avoid cross contamination and the dish is placed under an infrared radiator of about 65°C until it is completely dried and weighed to obtain the weight of the residue. Then 0.077 g of the residue is transfer into a sterilized planchette using a spatula and then weighed. The residue is then uniformly spread on the planchette to obtain a uniform surface area of the sample for effective detection of the activities of the samples (vinyl acetate is added in order to bind the particles together and remove any moisture content). Sterilizations were done using acetone to avoid contamination of any form.

$$C = \frac{(R_b - R_0) \times a_s \times m \times 1.02}{(R_s - R_0) \times 1000 \times v} \quad (3)$$

Where;

$R_b$  is observed sample count rate ( $S^{-1}$ )

$R_s$  is observed standard count rate ( $S^{-1}$ )

$R_0$  is background count rate ( $S^{-1}$ )

$a_s$  specific activity of the standard solid

V is volume of sample in liters,

And m is mass in milligrams of ignited residue from volume V.

In order to correct for the 20 ml of the nitric acid added to the sample as a stabilizer it is important that the factor 1.02 be included in the final equation as shown in equation 3.

### 3. RESULTS AND DISCUSSION

The concentration of the ten samples used for the gross beta counting in each water sample according to the locations, values and associated errors are presented in Table 1. The distribution of the activities of the beta concentration are both represented in pie charts and line graphs as shown in Figs. 1- 6.

The concentration of beta measured in water sample in hand-dug wells ranged from 0.265±0.027 Bq/L in N10 well to 0.976±0.103 Bq/L in N14 well, the mean value of beta activity

in hand-dug well is 0.638±0.109 Bq/L as shown in Fig. 2 and Fig. 1 shows the percentage values of beta activity for hand-dug well samples in the study area.

The concentration of beta measured in borehole water samples ranged from 0.200±0.041 Bq/L in Ebenezer borehole to 1.530±0.141 Bq/L in Transformer borehole, the mean value of beta activity in borehole was 0.589±0.099 Bq/L as shown in Fig. 4 and Fig. 3 shows the percentage value of beta activity in borehole samples in the study area.

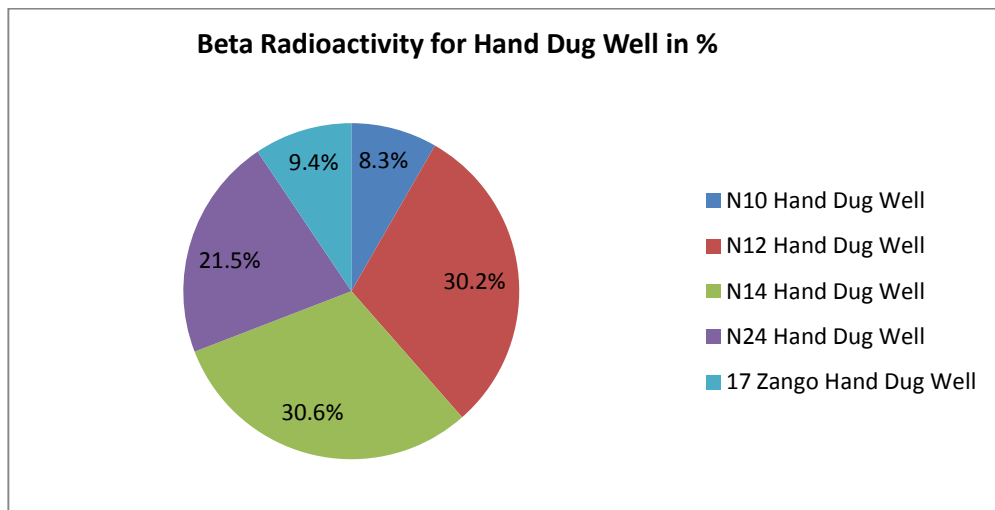


Fig. 1. Pie chart showing beta concentration in % for hand dug well

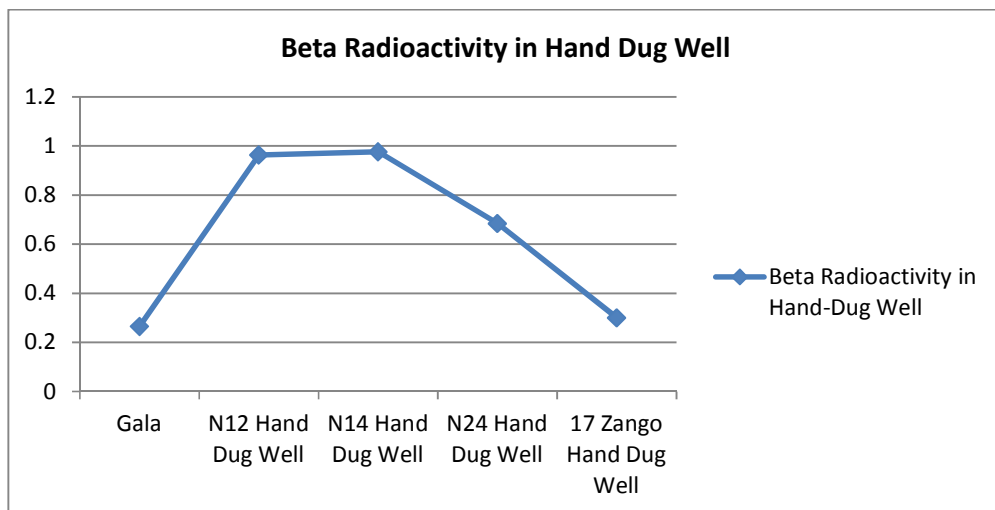


Fig. 2. Line graph shown beta concentration in Bq/L for hand dug well

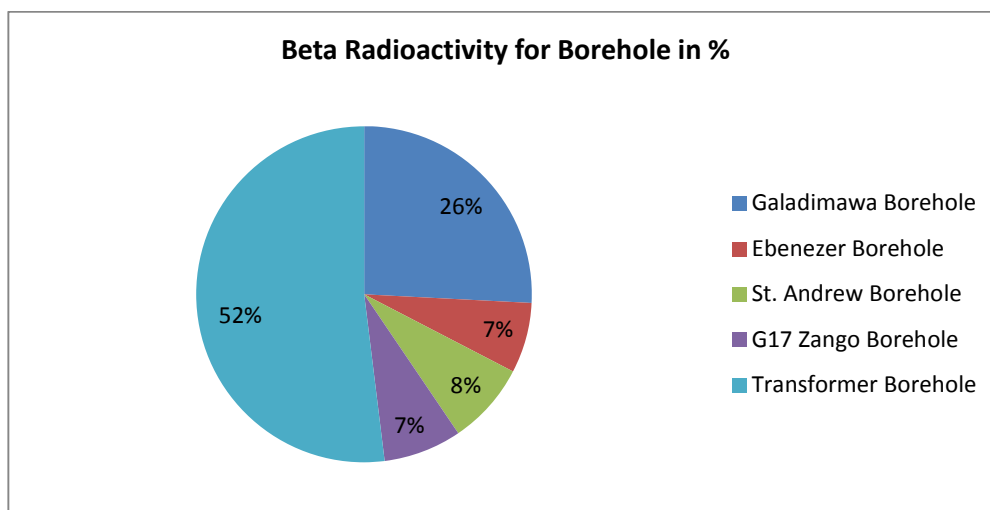


Fig. 3. Pie chart showing beta concentration in % for borehole

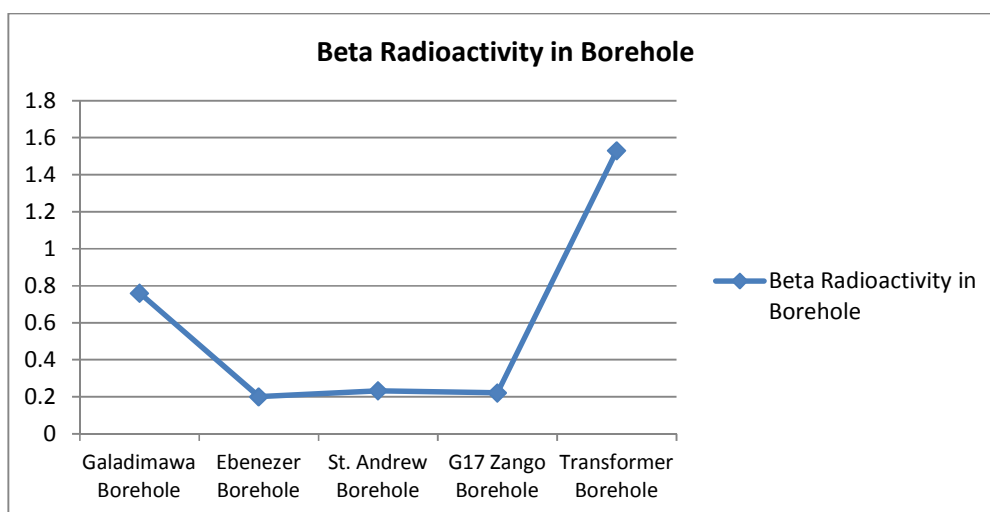


Fig. 4. Line graph shown beta concentration in Bq/L for borehole

Table 1. Beta radioactivity in water samples

Sample identification	Beta concentration (Bq/L)
N10 well	0.265 ± 0.027
N12 well	0.963 ± 0.142
N14 well	0.976 ± 0.103
N24 well	0.684 ± 0.130
17 Zango well	0.300 ± 0.144
Galadimawa borehole	0.760 ± 0.141
Ebenezer borehole	0.200 ± 0.041
St. Andrew borehole	0.233 ± 0.096
G17 Zango borehole	0.221 ± 0.077
Transformer borehole	1.530 ± 0.141
Average	0.613 ± 0.104

The distributions of beta measured for both hand-dug wells and boreholes water samples are presented in Table 1, the beta activities ranged from 0.200±0.041 Bq/l to 1.530±0.104 Bq/l with a mean value of 0.613±0.104 Bq/l as shown in Figs. 5 and 6 shows the percentage value of all the samples both hand-dug well and borehole in the study area. From the result the mean value of the activities of the beta concentration for hand-dug well is greater than the borehole water sample in this study. In summary, the beta concentration meets the set standard by WHO and ICRP despite that the Transformer borehole water sample has the highest beta concentration and Ebenezer borehole has the lowest, the mean average still does not exceeded the minimum

standard set i.e 1.0 Bq/L per year. Every other water sample met the standard set by WHO [18] and ICRP [19] i.e 1.0 Bq/L except the water sample from the transformer borehole which shown that beta activity in that area is high, we can therefore deduce that the water sample from transformer borehole is not drinkable because it poses a serious threat to the health of the consumer. This shows that the deeper we dig the more concentration of radioactive materials

encountered. Also compared the average value 0.613 Bq/l of beta activity obtained in this work with 6.0 Bb/L for well in Western Niger Delta by Agbalagba et al. [9]; 0.236 Bq/L in Ado-Ekiti by Fasae [11]; 2.3695 Bq/L in Nassarawa by Ahmed et al. [12]; 11.16 Bq/L in Gboko and its Environs of Benuel by Ator et al. [15]; and 0.0478 Bq/L in Kano by Yusuf et al. [20], which shows that the gross beta activity obtained in this selected area of this study is lower.

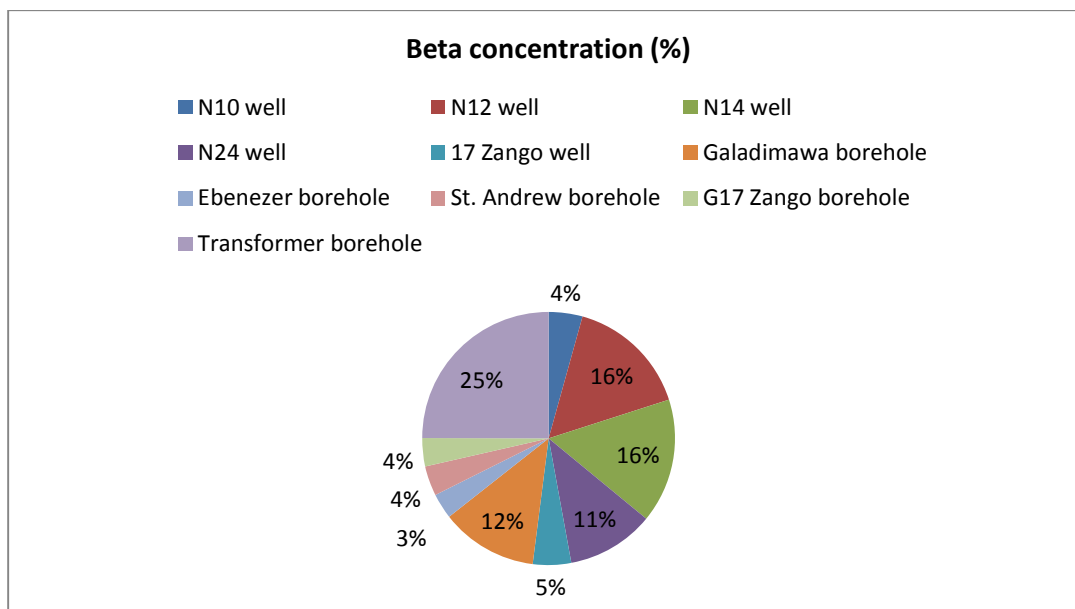


Fig. 5. Pie chart showing beta concentration in % for all the samples

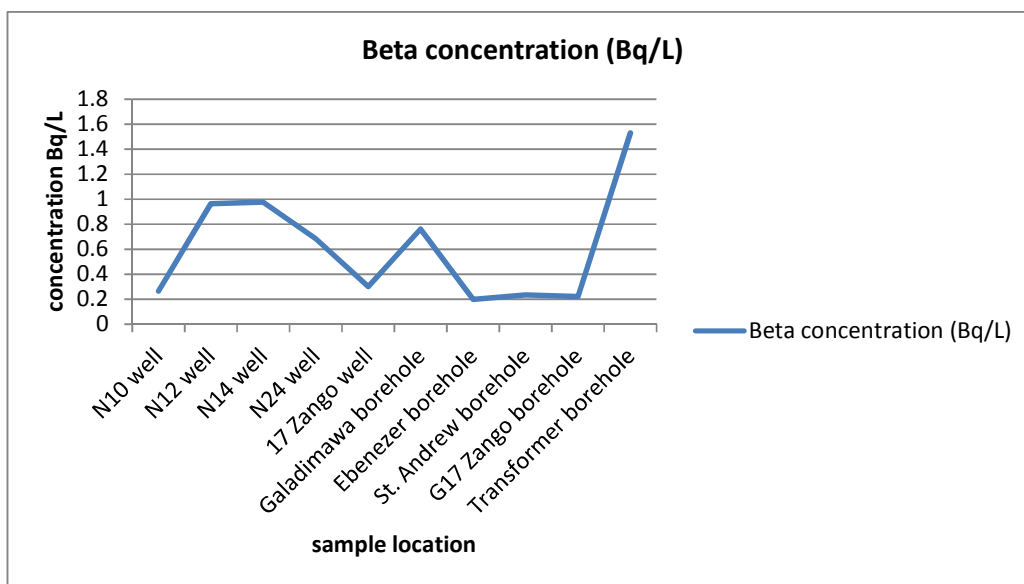


Fig. 6. Line graph shown beta concentration in Bq/L for all the samples

#### 4. CONCLUSION

Gross beta spectrometry had been used to determine the radioactivity concentrations of water samples commonly consumed in some area of kakuri in Kaduna south Kaduna state. The analysis of these water samples showed that the beta activity was below the recommended activity concentrations in water samples by the ICRP and WHO except for the sample obtained from transformer borehole. This particular water sample is not safe for drinking, but can be used for other purpose like washing. Therefore, there is the need for determination of radionuclide responsible for the high beta activity concentration in the water of the affected area and other water samples are safe for drinking and can be used for other purposes like cooking, washing etc. The federal government should partner with the researchers and sponsor enlightenment programs in other to create awareness and to safeguard the health of the citizen, repeat of this research work should also be carried out both during rain and dry season so as to survey the gross beta activity in the water and to also find out more about the variations of radionuclide in water and also establishment of monitoring programs to ensure the water treatment, is carried out if required is necessary.

#### ACKNOWLEDGEMENT

The authors thank Mr. Sirajudeen and Dr (Mrs.) Rose Ada Onoja at the Centre for Energy Research and Training CERT, Zaria, who took out time to analyze the water samples.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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