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RADIONUCLIDE ANALYSIS OF DRINKING WATER IN SELECTED SECONDARY SCHOOLS OF EPE LOCAL GOVERNMENT AREA, LAGOS STATE, NIGERIA

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Abstract: A total number of 20 water samples were collected from different locations, spreading over selected twenty public secondary schools in the Local government area of Epe in South Western, Nigeria. Ten well water samples were collected from selected rural school area and ten borehole water samples in urban schools area. The concentrations of natural radionuclides were determined using gamma ray spectrometer comprising a 7.6 cm x 7.6 cm Nal (TI) detector coupled to a multichannel analyser for spectral analysis. Data were analysed using descriptive statistics. The activity concentrations from boreholes and wells with depths ranging between 17.68 and 38.1 metres were randomly sampled and determined from 20 locations in public schools in Epe LGA. The activity concentration obtained were in the ranges of (38.3 – 292.8) Bq/L with mean value of 13.4 ± 10.8 Bq/L for ^{40}K, 1.2 – 36.7 Bq/L with mean value of 6 ± 1.4 Bq/L for ^{238}U and 1.2 – 11.7 Bq/L with mean value of 4.5 ± 1.2) Bq/L for ^{232}Th. The values obtained for the mean activity concentrations for the radionuclides from the 20 boreholes and well water samples in Epe, revealed that ^{40}K, ^{238}U and ^{232}Th values were below the United Nations Scientific Committee on the Effects of Atomic Radiation recommended international limits of 370Bq/L and within the tolerance level indicating minimal radiological health burden.

Keywords: Borehole water, Epe, Health hazard, Natural radionuclide, Secondary school, Well water.

1. INTRODUCTION

Water plays a vital role by conserving lives and their environment. Water for human consumption must be free from hazardous chemical substances. The quantity and quality of water are a prime factor in the selection of any source of water supply [1]. The quality of drinking water is a powerful environmental determinant of health [2] and adequate supply of safe water is essential for the promotion of public health. Ground water is the most important source of domestic and agricultural water supply in the world [3]. Although it is easily accessible from lakes, rivers, streams and springs borehole water is of better quality. Rock weathering atmospheric precipitation, evaporation and crystallization control the chemistry of water. The influence of geology on chemical composition of water is widely recognized [4]. Although radionuclides are widespread, there are large gaps in our knowledge about sources of these materials, their distribution, associated health risks, and mitigation measures. However, the information we do have suggested that current drinking water standards for radionuclide established by the U.S. Environmental Protection Agency (EPA) may not adequately protect health. Naturally occurring radioactive materials had been vital components of the environment and earth crust as far back as when the earth was created. These naturally occurring radioactivity materials disintegrate and emit ionizing radiation to the environment [5]. The concentration of radionuclide in an area depends on the geological setting of the area. Eight five percent of radiation exposure to man are from naturally occurring radioactive materials while the remaining fifteen percent is from cosmic rays and the man made sources [6, 7].

Natural radionuclide levels have been studied in surface soils in Ijero Ekiti, in soil and water around cement company in Ewekoro, Port Harcourt and in rocks in Ekiti respectively [8, 9, 10]. Results from their studies revealed non significant levels of radionuclides in the environment. Recent study carried out on the activity concentrations of natural radionuclide levels in well waters of Ago-Iwoye, Nigeria showed that radiological health burden on the human populace is very minimal and has neither health implications nor affects the background ionization radiation [5]. The behavior of radium in ground water is of considerable interest to researchers worldwide. Ingestion of radium has long been a recognized health risk [11]. This has prompted numerous regulatory agencies including the World Health Organization (WHO) and the U.S. EPA to establish drinking water limits for radium [12]. WHO limits are 27 and 2.7 pCi/L for ^{226}Ra and ^{228}Ra, respectively, and U.S. EPA limits are 5 pCi/L combined.

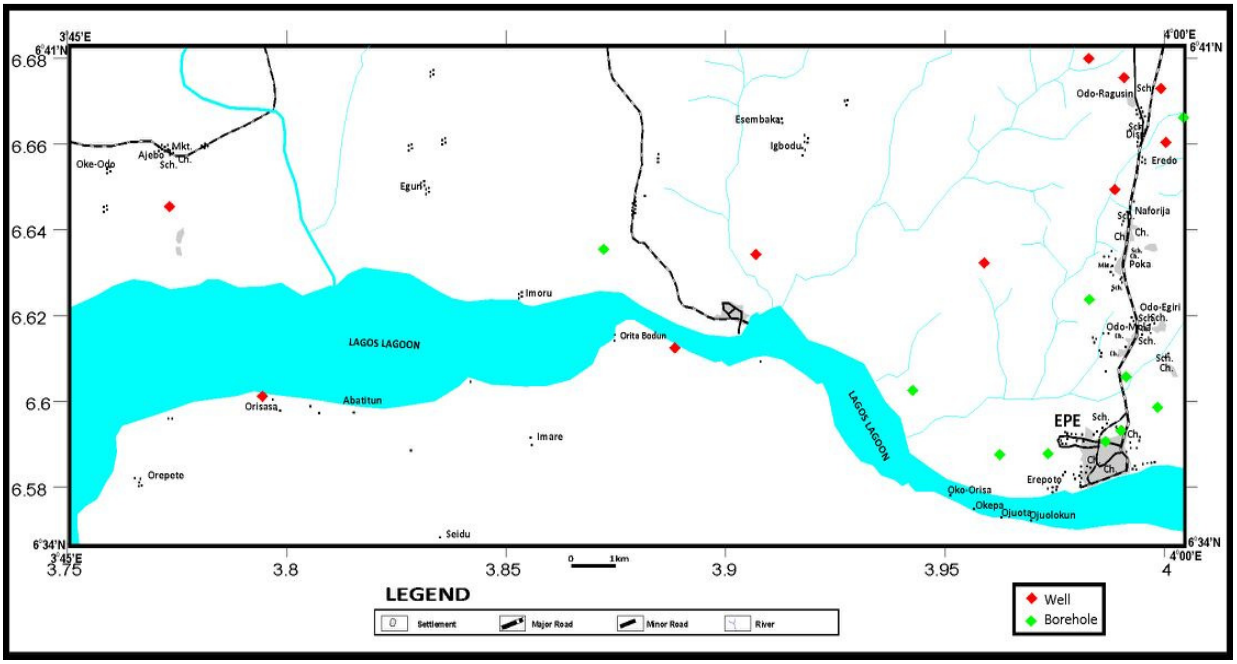

Fig. 1: The geographical location of the towns and water samples (Source: Field survey, 2014).

In Nigeria however, Lagos to be precise, the state Government through its 'Eko Project Fund' has made significant efforts to improve the learning/ teaching standard in public schools and one of these is provision of drinking water via sinking of boreholes and well water for the students. It is not under statement that some of these boreholes and well water were not properly sunk under a hygienic condition whereas the water elements are dangerous for the students thereby causing them consistent health issues.

According to Davis and Royer [13] drinking water standard are based on two main criteria namely; the presence of objectionable tastes, odour, and colour; and the presence of substances with adverse physiological effects. However, mineral enrichment from underlying rocks can change the chemistry of water, making it unsuitable for consumption [14]. Water can also be a serious environmental and health problem if the design and development of such water supply system is not coupled and tied with appropriate sanitation measures [15]. According to [16], drinking water can acts as a passive means of transporting nutrients into the body system. However, the objectives or primary concern in providing portable water are freedom from harmful microorganisms and freedom from undesirable or harmful chemicals. Therefore, both the water quality and sanitary condition are important and monitoring must be given the highest priority.

Hence the aim of the study is to determine the activity concentration of the radionuclide that are contained in the well and borehole water consumed in the public schools in order to ascertain the health side effects on students and the people in the environment.

2. MATERIALS AND METHODS

The measurement of activity concentrations of natural radionuclides of the drinking water entailed both the field and laboratory procedures. The field procedure involves preliminary survey of the study area, sampling and sample collection. The preliminary and familiarization process was carried out before collection of samples was done.

2.1 On site observation

This involved the assessment of the immediate surroundings of the water source from man and animal activities within the vicinity of the water supply assessed. Observations included examination of the plinths of boreholes and wells to ascertain if they are cracked, eroded or watertight, observation for signs if water accumulation close to them, identification of activities such as washing of cloths, urination, brushing of teeth within 5 metres to the water source, with potential to affect water quality. Others were assessment of activities of animals e.g. cows goat rams and dogs around the water collection points, and closeness of the points to dung, septic tanks, sewers or waste dumps and the neighbours were drinking from these water sources. In addition to these properties such appearance, odour and taste were assessed according to [17].

2.2 Area of study

The study area is located in Lagos state, southwestern Nigeria with special consideration on twenty (20) selected schools from Eredo Local Council development Area (LCDA) and Epe Local Government Area of Lagos State. Epe is a town and Local Government Area (LGA) in Lagos State, Nigeria located at 6°350'N 3°59'E coordinates North side of the Lekki Lagoon. During the 2006 Census, the population of Epe was 181,409. This area is presented in the map Fig. 1.

2.3 Sample collection and preparation

2.3.1 Sampling Procedures

Random sampling technique was employed in this study. The technique is suitable because it allowed equal representation of public secondary schools within the scope of the study since not all the schools could be covered for the study. Ten schools were selected in each area to make a total of twenty schools sampled in the study. At the Radiation and Health Physics Laboratory, Ibadan Oyo state, 250 ml (250 gm) of each water sample was measured with measuring cylinder. The water samples were then transferred into uncontaminated empty cylindrical plastic containers of uniform size (60 mm height by 65 mm diameter). The containers were then sealed for about 21 days to allow 222Rn and its short lived progenies to reach secular equilibrium prior to gamma spectroscopy. The sampling locations are shown in Table 1. Fig. 1 shows the geographical location of the towns and water samples used in the school area:

2.4 Determination of the specific activity concentration of each radionuclide

The calibration of the low level gamma spectrometry system was carried out using certified standard calibration radioactive solutions of Cs.137 (Ref No.: Ro/3129/7), U-238 (RGU-1) and Th-232(RGTh-1) and EU-152 (Ref No.: EA3/1496/20866) supplied by Radiochemical center Amershan England through the technical aid of International Atomic Energy Agency (IAEA) Vienna, Austria. The samples (well water) were counted for 1800 seconds (5 hrs) using a low level gamma spectrometry system consisting of a 76mm x 76 mm Nal(TI) detector (model No. 802 –series, Canberra inc.) coupled to a Canberra series 10 plus Multi-Channel Analyser (MCA) Model No. 1104 through a resolution of about 8% at o.662 MeV, which is capable of distinguishing the gamma ray energies of the radionuclides of interest in this study.

The photopeak at I.46MeV was used for measurement on K-40 while those at 1.76 MeV peak from 214Bi and 2.614 MeV from 208TI were used for the measurement of ^{238}U and ^{232}Th respectively. The net area under each photopeak, after background correction, was used to calculate the activity concentrations of each radionuclide in the water sample. The specific activity of the radionuclide in each water sample was calculated using the expression [18].

Table 1: Location of schools, water samples and depth

S/N	Location	Water sample	Depth (metre)
1	Alaro community High School Iraye-Oke	Bore-hole	35.05
2	Odomola secondary school Odomola	Bore-hole	35.05
3	Pobuna Community Grammar school	Bore-hole	34.75
4	Araga Grammar School	Well	17.68
5	St. Patrick College Eredo	Well	36.88
6	Okemagba High School Mojoda	Well	36.27
7	Nazareth College Ibonwon	Well	35.66
8	Igboye community High School	Well	36.58
9	Adesowon Grammar school Ilara	Well	36.58
10	Lagos State Model College, Igbonla	Bore-hole	35.97
11	Molajoye High School	Well	22.86
12	Government College, ketu	Bore-hole	32.00
13	Ajebo High School Agbowa Road	Well	20.73
14	Sala High School	Well	21.64
15	Lofi Ogunmude College School	Well	28.96
16	Temu Secondary	Bore-hole	26.82
17	Ogunmodede College School	Bore-hole	38.10
18	Epe Girls High School	Bore-hole	37.49
19	Odo-Obara High School	Bore-hole	33.52
20	Epe Grammar School, Epe.	Bore-hole	33.52

BDL: Below detection limit

$$c = \frac{A}{V_{\gamma} T E_p} \quad (1)$$

where C = specific activity of the radionuclide in Bqkg-1,
A = Net area under the photo peak of each radionuclide
V = Volume of water sample
T = Counting time
γ = Gamma yield or absolute probability of the specific gamma ray
E_p = Efficiency at specific gamma ray energy in Bqkg-1.

3. RESULTS AND DISCUSSION

The results were presented in tables compared with local and international standards for drinking water quality and subsequently discussed.

3.1 Results

Radioactivity levels of ^{40}K, ^{238}U and ^{232}Th in the water samples collected from different schools area presented. Table 2 showed the radionuclide analysis of well water in ten selected secondary schools in Epe Local Government Area while Table 3 is the analysis of Borehole water in ten selected secondary schools in Epe Local Government Area.

Table 2: Activity concentrations of the radionuclides in the well water sample.

Sample Code	^{40}K (BqL^{-1})	^{238}U (BqL^{-1})	^{232}Th (BqL^{-1})
S_{W1}	BDL	BDL	BDL
S_{W2}	47.59 ± 2.58	0.52 ± 0.07	4.88 ± 0.30
S_{W3}	BDL	1.27± 0.015	2.42 ± 0.15
S_{W4}	BDL	BDL	BDL
S_{W5}	BDL	2.62 ± 0.31	4.92 ± 0.30
S_{W6}	BDL	13.07 ± 1.41	5.42 ± 0.33
S_{W7}	BDL	BDL	BDL
S_{W8}	68.09 ± 3.67	4.12 ± 0.48	8.01 ± 0.49
S_{W9}	BDL	2.88 ± 0.32	7.16 ± 0.44
S_{W10}	BDL	5.70 ± 0.67	10.25 ± 0.63

BDL: Below detection limit

Table 3: Activity concentration of the radionuclides in the borehole water samples

Sample Code	^{40}K (BqL^{-1})	^{238}U (BqL^{-1})	^{232}Th (BqL^{-1})
S_{H1}	BDL	5.18 ± 0.58	4.82 ± 0.29
S_{H2}	184.43 ± 9.96	1.47 ± 0.17	5.36 ± 0.33
S_{H3}	BDL	BDL	1.21 ± 0.08
S_{H4}	BDL	BDL	BDL
S_{H5}	BDL	13.44 ± 1.42	8.92 ± 0.55
S_{H6}	292.84 ± 15.89	36.73 ±3.51	11.72 ± 0.72
S_{H7}	42.97 ± 2.34	17.68 ±1.93	8.18 ± 0.50
S_{H8}	BDL	BDL	BDL
S_{H9}	BDL	11.92 ± 1.37	8.28 ± 0.51
S_{H10}	BDL	10.25 ± 1.09	5.45 ± 0.34

BDL: Below Detection Limit.

The activity concentrations of the radionuclides both from the wells and boreholes were calculated with error from the spectroscopic system.

3.2 Discussion

The acceptability and use of water for domestic needs and other recreational are influenced by both physicochemical and bacteriological parameters. A major factor affecting water quality is anthropogenic activities arising from rapid industrialization and urbanization coupled with poor sanitary practices [19]. Improper waste management techniques and poor sanitation practice characteristic of many livestock farms in Nigeria that results in massive discharge of animal wastes into rivers and erosion courses further pose very serious threat to water quality [20]. Table 2 shows the activity concentrations of the radionuclide 40K, ^{238}U and ^{232}Th in the well water collected from rural secondary schools. The concentration of ^{40}K in Nazareth College, Ibowon (SW1) was BDL, and between the ranges of BDL in ^{238}U and BDL in ^{232}Th. Radioactivity levels of ^{40}K, ^{238}U and ^{232}Th in the well water samples collected for St. Patrick College, Eredo (SW2) are in the range of 47.59 + 2.58 BqL-1 for ^{40}K; 0.52 + 0.07 BqL-1 for ^{238}U and 4.88 + 0.30 BqL-1 232Th.

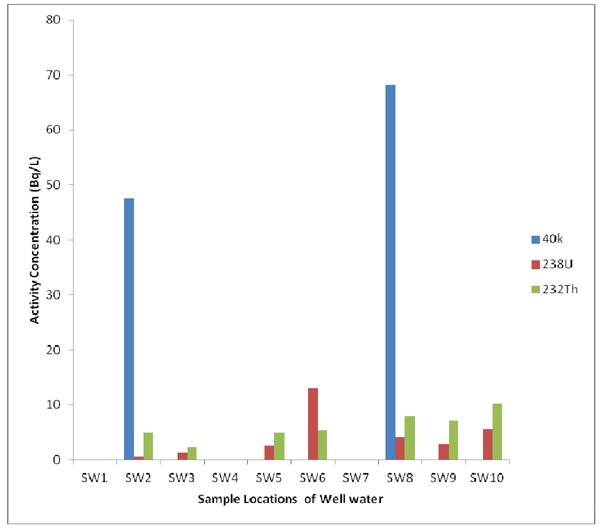

Fig. 2: Activity concentration of radionuclide in well water samples in public schools in Epe.

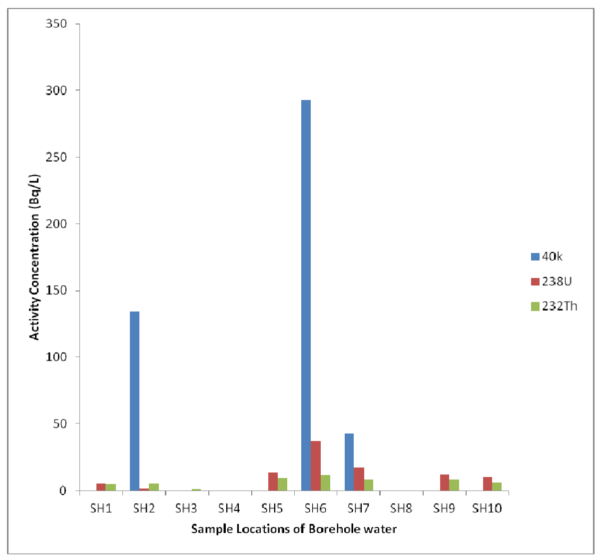

Fig. 3: Activity concentration of radionuclide in borehole water samples in public schools in Epe.

Okemagba High School, Mojoda (SW3), radioactivity concentration for ^{40}K is BDL, ^{238}U is 1.27 + 0.01 BqL-1 while radionuclide activity presence of 232Th is between the range of 2.42 + 0.15 BqL-1.

Also in Araga Grammar School, Araga (SW4), the radioactivity concentrations levels for 40K, ^{238}U and ^{232}Th were below detection limit. In Igboye Community High School (SW5), the radionuclide concentrations present in well water are BDL for 40K; 2.62 + 0.31 BqL^{-1} for ^{238}U and ^{232}Th is 4.92 + 0.03 BqL^{-1} respectively.

The result for Molajoye High School (SW6) shows that the level of potassium activity 40K was below detection limit while that of uranium ^{238}U is 13.07 + 1.41 and Thorium ^{232}Th 5.42 + 0.33 BqL-1. Just like Araga Grammar School, Araga (SW4) the Potassium, Uranium and Thorium activity for Lagos State Model School, Igbonla (SW7) were BDL. Sala High School, Sala (SW8) of well water result shows that the ^{40}K activity is 68.09+ 3.67 BqL-1 while uranium level of is between 4.12+ 0.48 and 8.01 + 0.49 for Thorium ^{232}Th. Adesowon Grammar School, Ilara (SW9) result shows that the radionuclide activity for ^{40}K, ^{238}U and ^{232}Th are 38.34 + 2.01, 2.88 + 0.32 and 0.16 + 0.44 BqL-1 respectively. Lastly on the well water sample results for Lofi Ogunmiude College, Ikosi Ejinrin (SW10) shows that the radionuclide activity for 40K is BDL while ^{238}U and ^{232}Th are 5.70 + 0.67 and 10.25 + 0.63 BqL-1 respectively. Fig. 2 is the graphical representation of activity concentration measured in BqL-1

The calculated mean activity concentrations values of 11.5 + 2.8 Bq L-1 for ^{40}K, 3 + 0.6) BqL-1 for ^{2382}U and 4.3 + 0.3 BqL-1 for 232Th for well water samples and mean activity concentrations values of 52 + 2.1 BqL-1 for 40K, 9.6 + 0.7 BqL-1 for ^{2382}U and 5.4 + 0.4 BqL-1 for ^{232}Th for borehole water in Epe, revealed that ^{40}K, ^{238}U and ^{232}Th values were below the United Nations Scientific Committee on the Effects of Atomic Radiation recommended international limits of 370Bq kg-1.

From Table 3 which shows the radionuclide concentrations of ^{40}K potassium, ^{238}U Uranium and ^{232}Th. Fig. 3 highlights the activity concentration of the water samples from boreholes in selected public schools

Result from Alaro Community High School, Iraye-Oke (SH1) shows the amount of ^{238}U available in the borehole water which is in the range of 5.18$\pm$0.58Bq/L and that of ^{232}Th is 4.82$\pm$0.29Bq/L. The potassium level ^{40}K is below detection limit for the school, ^{40}K is 134.43 $\pm$ 9.96 BqL^{-1} while ^{238}U and ^{232}Th are 1.47 $\pm$ 0.17 BqL^{-1} and 5.36 $\pm$ 0.33 BqL^{-1} respectively.

In Pobuma Community Grammar School, Poka (SH3) potassium and uranium are both below detection limit i.e BDL while the radionuclide level of thorium ^{232}Th, is in the range of 1.21 $\pm$ 0.08BqL^{-1}. All ^{40}K, ^{232}Th in borehole water of Epe Girls high School (SH4) were below detection limit (BDL).

Government College Ketu, (SH5) borehole water also shows that ^{40}K is BDL, ^{238}U is 13.44 $\pm$0.42 BqL^{-1} and ^{232}Th is 6 is 292.84 $\pm$15.89Bq/L of potassium, ^{40}K, 36.73 $\pm$3.52 BqL^{-1} for uranium and 11.72 $\pm$0.72Bq/L for thorium. Borehole water sample for Ogunmodede College, Epe (SH7) is 42.97 $\pm$2.34 BqL^{-1} of ^{40}K, 17.68$\pm$1.93 BqL^{-1} of ^{238}U and 8.18 $\pm$ 0.50Bq L^{-1}. Borehole water sample for Ajebo High School, Agbowa (SH8) is BDL for ^{40}K, ^{238}U and ^{232}Th respectively. Borehole water sample for Odo-Obara High School, Epe (SH9) is BDL for ^{40}K, 11.92 $\pm$ 1.37 of ^{238}U and 8.28 $\pm$ 0.51 BqL^{-1} of ^{232}Th, and finally borehole water sample for Epe Grammar School, Epe (SH10) is BDL for ^{40}K, 10.25 $\pm$ 1.09 BqL^{-1} and 5.45 $\pm$ 0.34 BqL^{-1} for ^{232}Th. The calculated mean activity concentrations values of 52 $\pm$ 2.1 BqL^{-1} for ^{40}K, 9.6 $\pm$ 0.7 BqL^{-1} for ^{2382}U and 5.4 $\pm$ 0.4 BqL^{-1} for ^{232}Th for borehole water in Epe, revealed that ^{40}K, ^{238}U and ^{232}Th values were below the United Nations Scientific Committee on the Effects of Atomic Radiation recommended international limits of 370 BqL^{-1}.

The activity concentration of radionuclides obtained in this study compared with the studies of [8], [9], [10] and [19] showed that values though difefering slightly for different concentrations of ^{40}K, ^{238}U and ^{232}Th were still very much within acceptable limits. This is also in agreement with the findings of Fasunwon et al., (2010[5]) on radiological health burden on the human populace.

The mean absorbed dose rate calculated using activity concentrations for the samples ranges from 3.52 $\pm$ 0.26 to 23.35 $\pm$ 3.62 nGy h^{-1} resulting to a corresponding annual effective dose equivalent of 3.2 $\mu Sv\ yr^{-1}$ to 4.2 $\mu Sv\ yr^{-1}$. These values were below the recommended limits and when compared with the findings of [21] have not significantly affected the natural dose levels in the area, hence the dose to population is therefore considered low.

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study was carried out to determine water quality and the activity concentrations of radionuclides and the health hazard indices of samples of water in Epe Local Government of Lagos State. Southwestern Nigeria. Radionuclide analyses of water samples were carried out on 20 water samples from wells and boreholes in selected 20 schools were collected from the study area and analyzed. Generally, the activity concentration of ^{40}K is more pronounced than the concentration level in either ^{238}U or ^{232}Th. The results showed that all the mean activity concentration values of all the water samples both in well and boreholes are within the recommended values by World Health Organization (WHO) and not exceeded both local and international standards.

5.2 Recommendation

Based on the outcome of the findings, this study should be spread to more schools in the State. There is also the need for constant environmental monitoring by the regulation agency to prevent people from radiation health hazards. However, the present data provide useful information to investigate future occurrence of radioactive elements in the local council area.

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