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ASSESSMENT OF NATURAL RADIONUCLIDES LEVELS IN DRINKING WATER FROM OGUN STATE, NIGERIA

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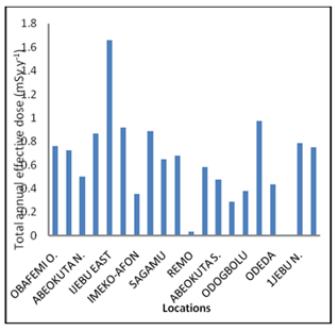
Graphical abstract



Abstract

Naturally occurring radionuclides levels of 238U, 232Th and 40K were investigated in the water samples collected at different boreholes in all the local government of Ogun State using high-purity germanium (HPGe) detector (Canberra Industries Inc.). The activity concentrations measured from the water samples ranged from 0.06 to 1.37 Bq l-1 for 238U, 0.15 to 0.52 Bq l-1 for 232Th and 1.35 to 12.74 Bq l-1 for 40K. The measured activities concentrations for 238U, 232Th and 40K along with their ingested dose conversion factors were used to estimate the annual effective doses in accordance with International Commission on Radiological Protection (ICRP) based on age groups 0 -1y, 1 – 2y, 2 – 7y, 7 – 12y, 12 – 17y and >17y for water consumption. The total annual effective doses calculated varied from 0.004 to 0.517, 0.002 to 0.092, 0.001 to 0.078, 0.001 to 0.076, 0.024 to 0.110 and 0.002 to 0.117 for the age groups accordingly. The physiochemical results showed that 85% of the water was acidic as they have pH less than 6.5 and 65 % of them exceeded the copper concentration recommended limit. It revealed that consumption of the water is safe from natural background radiation for all groups except 0-1 y as the annual effective dose obtained for this group exceeded the average world limit (0.12). The study therefore, suggests that Ogun State populace should use less of these water samples for babies between the age 0-1 year.

Keywords: Natural radionuclide, drinking water, annual effective dose, Ogun State

1.0 INTRODUCTION

Water is an essential ingredient for living organism and human society. Economic development of a nation depends on this resource. It has been reported that the total quantity of water on the earth is approximately over billion cubic meters [1]. Sources of water comprise of rivers, wells, springs, rivers and borehole [2]. These sources provide water for drinking, domestic uses and also pathways through which contaminants can reach the population [3]. In the recent times contamination levels of naturally occurring radionuclides in the water have been studied by researchers because of the increase in cancer patients and other water bore diseases in the world today [4, 5, 6, 7]. Due to human activities water has been contaminated with solid and human wastes, effluents from chemical industries and dissolved gases [8]. Through these activities, trace elements have found their way underground into the water which may in turn have effect on human health either through ingestion, inhalation, injection or absorption [5, 9]. The quality of water most especially for drinking purposes should be checked from time to time in order to assess the radioactivity contents and the level of these activities such as organic, inorganic, microbial and bacterial pollutant through which trace elements emanates. Thus, this study measured the radioactivity contents (238U, 232Th and 40K) and physiochemical properties of drinking water collected from boreholes in Ogun State, Nigeria in order to assess the radiological impact of the water on the health of the age groups in the studied areas.

1.1 Geology and Physical Setting of the Study Area

Ogun state is located on latitude 7.00o N and longitude 3.35o E in south western Nigeria. It has twenty local government headquarters with a population of 3,751,140 people. The mean annual rainfall and temperature are about 1,270 mm and 28°C respectively while the estimated mean annual potential evaporation is 1,100 mm. It borders Lagos State to the South, Oyo and Osun states to the North, Ondo State to the east and the republic of Benin to the west. The Location is within the Dahomey basin and the stratigraphy of the basin has been grouped into six (6) lithostratigraphic formations namely from oldest to youngest Abeokuta, Ewekoro, Akinbo, Oshosun, Ilaro and Benin formations (Figure 1).

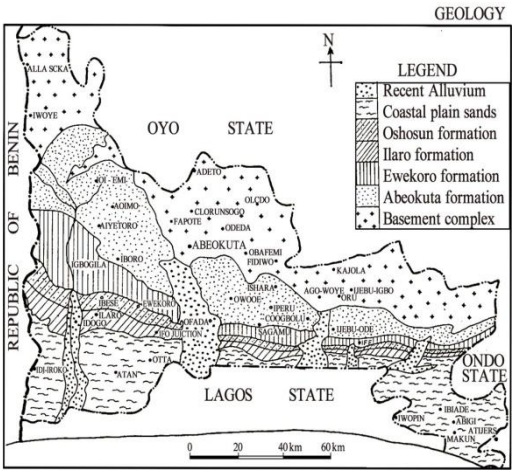


Figure 1 Geological Map of Ogun State (After Obaje)

2.0 MATERIALS AND METHOD

Five (5) water samples were taken from different points at each location for better sampling, using 1.5 litre plastic and labelled accordingly making a total of one hundred (100) water samples from all the locations. The in-situ parameters measured includes pH, electrical conductivity (EC), and temperature of the samples using pH meter, Conductivity meter, and thermometer respectively in order to obtain the physiochemical properties. Atomic absorption spectroscopy (AAS) which uses the absorption of optical radiation (light) by free atoms in the gaseous state was used to analyzed trace elements concentration(Ca, Cr, Cu, Fe, and Zn) in the water samples.

2.1 Activity Measurement

Water sample of one (1) l each was transferred into marinelli beaker. The samples in the containers were air tight and kept 28 days in order to reach secular equilibrium. Radioactivity counting was done using 80 % efficiency p-type high purity germanium (HPGe) detector (Canberra model GC8023 serial number 9744) coupled to a multichannel analyzer (MCA) was used for radioactivity measurements. The HPGe detector had an energy resolution of 2.2 KeV (FWHM) for the 1332.5 KeV gamma-ray transition of 60Co source. Each sample was counted for 36,000 s and the activity concentration were calculated using the photo peaks corresponding to 226Ra (186 keV), 214Bi (1238 keV and 1378 keV), 214Pb (295 keV and 351 keV) for 238U; 208Tl (860 keV), 228Ac (338 keV, 911 keV, 969 keV) for 232Th and 1460 keV for 40K with Genie 2000 software.

2.2 Evaluation of Total Annual Effective Dose

The annual effective dose H $(mSvy^{-1})$ to an individual in consumption of ^{238}U, ^{232}Th in the borehole water was estimated using equation 1.

$$H = R_a A_i C_f \quad (1)$$

R_a is the radioactivity concentration of radionuclide in the water sample (Bq l^{-1}), A_i is the annual intake of the water sample (1 y^{-1}) and C_f is the ingested dose conversion factor for radionuclides $(mSvy^{-1})$, and varies with radionuclides and the age of individuals ingesting the radionuclides. Adding contributions from all radionuclides present in the water samples the total annual effective dose H_E $(mSvy^{-1})$ to an individual was found using equation 2.

$$H_E = \sum R_a A_i C_f \quad (2)$$

The dose conversion factors used in the calculation and the annual effective dose were adopted from International Commission on Radiological Protection [10] for six age groups 0 - 1y, 1 – 2y, 2 – 7y, 7 – 12y, 12 – 17y and > 17y old with annual average water intake of 200, 260, 300, 350, 600 and 730 litres respectively.

3.0 RESULTS AND DISCUSSION

The physiochemical analysis results on the water revealed that the measured pH ranged from 50.2 (acidic) to 7.35 (alkaline) with an average value of 5.82 ± 0.48. The pH value is an important index of acidity or alkalinity and the concentration of hydrogen ion in water [11]. It was found that water collected from Odeda (6.56), Ijebu North (6.59), Ota (6.54) and Ewekoro (7.35) only are within the WHO recommended limit of 6.5 to 8.5 for drinking water quality [12]. Ewekoro has the highest pH value (7.35) while the lowest pH (5.02) was obtained from Ijebu North east. The pH value obtained in Ewekoro may be attributed to the abundance of limestone in this location. The acidity of water may be because of the corrosion of the pipeline which corroborates the report

of Jones (1998) that acidic water causes corrosion of steel and iron materials. Electrical conductivity (EC) is a measure or the ability of water to carry an electric current; it is directly linked to the concentration of the ions and their mobility. The measured EC in this work ranges from 21.3 to 336 µS cm-1 with the highest value found in Ewekoro which can be as a result of accumulation of limestone which is metallic in nature and has the ability to conduct and the lowest was found in Imeko-Afon. Generally, there are variations within the electrical conductivity this may be due to geological parameters of each study area. The EC obtained for all the locations are within the WHO permissible limit (300 µS cm-1) for water [12]. All the metals measured except for iron and copper are within the values for uncontaminated soil/water [13]. About 65 % of the water exceeded the recommended limit (0.005 to 30 mg l-1) for copper concentration which may be as a result of variations in water characteristics, such as pH, hardness and copper availability in the distribution system [14, 15]. The high concentration of iron may be as a result of corrosion of pipelines which resulted in oxidation of Fe2+ to Fe3+ which turns the laundry and sanitary wares brown and this may also be link to acidity of the water.

3.1 Radioactivity Results

The results of measured activity concentrations of ^{238}U, ^{232}Th and ^{40}K in the water samples are presented in the Table 1. The measured activity concentrations ranged from 0.05 to 1.37 Bq l^{-1}, 0.15 to 0.52 Bq l^{-1} and 1.35 to 12.74 Bq l^{-1} respectively. The highest activity concentration (1.37 Bq l^{-1}) of 238U was found at Ijebu east, while Remo has the lowest (0.06 Bq l^{-1}). The highest concentration (0.52 Bq l^{-1}) value of 232Th was found at Ifo while the lowest (0.15 Bq l^{-1}) was obtained at Ewekoro. Ijebu-ode water sample has the highest concentration (12.75 Bq l^{-1}) of 40K while Abeokuta north has the lowest concentration (1.35 Bq l^{-1}). The activity concentrations of 238U measured in Ijebu East and Ikenne water samples exceeded the recommended limit of 1.00Bq l^{-1} by International Atomic Energy Agency [16]. Figure 2 displayed the comparison of total annual effective dose from each of the water samples in the examined areas. Ijebu Ode water sample gave the highest internal exposure, followed by Ikenne and Ifo water samples. Remo water sample gave the least internal exposure to consumers. The total annual effective doses to the six age groups due to intake of the water intake were presented in Figure 2 which is the pictorial representation of the calculated values. The total annual effective dose calculated varied from 0.004 to 0.517, 0.002 to 0.097, 0.001 to 0.078, 0.001 to 0.076, 0.024 to 0.11 and 0.002 to 0.117 for the ages 1-2y, 2 – 7y, 7 – 12y, 12 – 17y and > 17y respectively. The lowest total annual effective dose was consistently obtained in Remo water sample. Figure 3 showed that babies age (0 -1 y old) are the most internally exposed to the radionuclides as the mean for this group (0.335 mSv y^{-1}) exceeded the recommended limit of 0.12 mSv y^{-1} [17]. Uranium being naturally occurring radioactive contaminants, which is found in both ground water and surface water, has the potential to cause kidneys damage when consumers are expose to high doses of uranium in their drinking water.

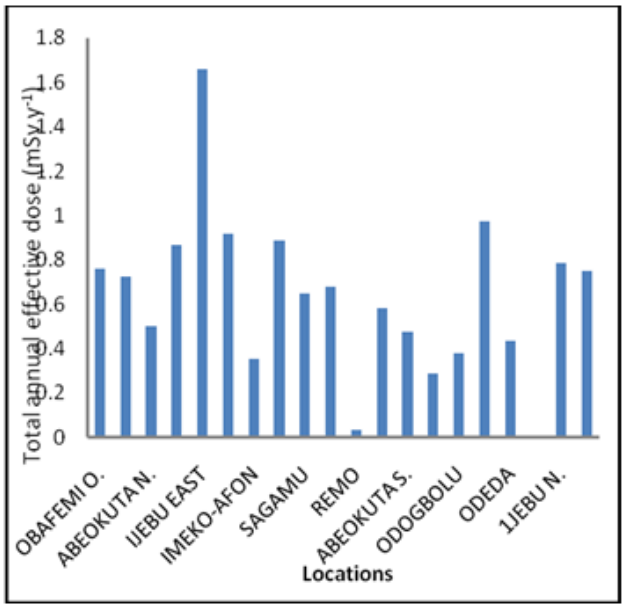


Figure 2 Total annual effective dose $(mSvy^{-1})$ the six age groups

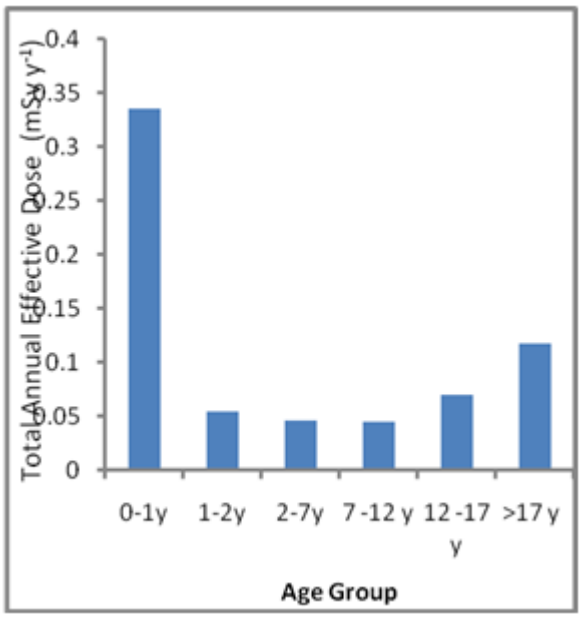


Figure 3 Comparison of total annual effective dose $(mSvy^{-1})$ from different samples

4.0 CONCLUSION

This study measured the radioactivity contents (^{238}U, ^{232}Th and ^{40}K) and physiochemical properties of

drinking water collected from boreholes in Ogun State, Nigeria using standard methods. It was observed that 85% of the borehole water was acidic and 65 % of them exceeded the copper concentration recommended limit. Electrical Conductivity obtained for Ewekoro water exceeded the WHO permissible limit (300 µS cm^{-1}) for water. The total annual effective dose (0.335 mSv y^{-1}) obtained for babies age (0 -1 y old) exceeded the recommended limit of 0.12 mSv y^{-1}. Thus, this finding suggests that babies (0 – 1y old) should consume less of these water samples.

Acknowledgement

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Table 1 Activity Measured in the Water [a]

Sample location	No of Samples	U-238(Bq l^{-1})	Th-232(Bq l^{-1})	K-40(Bq l^{-1})
OBAFEMI OWODE	5	0.70	0.39	6.52
YEWA NORTH	5	0.17	0.44	8.03
ABEOKUTA NORTH	5	0.51	0.25	1.35
IJEBU ODE	5	0.75	0.45	12.75
IJEBU EAST	5	1.37	0.31	3.69
IFO	5	0.42	0.53	7.87
IMEKO-AFON	5	0.27	0.19	6.17
YEWA SOUTH	5	0.71	0.47	8.03
SAGAMU	5	0.55	0.34	10.32
ADO-ODO	5	0.47	0.37	8.60
REMO	5	0.06	BDL	4.26
IJEBU NORTH EAST	5	0.73	0.27	6.04
ABEOKUTA SOUTH	5	0.27	0.27	9.32
EWEKORO	5	0.26	0.15	7.78
ODOGBOLU	5	0.17	0.22	6.55
IKENNE	5	1.27	0.45	9.08
ODEDA	5	0.40	0.23	8.62
IPOKIA	5	BDL	BDL	10.32
IJEBU NORTH	5	0.38	0.45	7.53
WATERSIDE	5	0.42	0.23	5.16
RANGE		0.06-1.37	0.15-0.52	1.35-12.74
MEAN ACTIVITIES		0.49	0.30	7.40
STANDARD DEV.		0.36	0.15	2.58

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