# Assessment of Radioactivity of Some Surface Soils in Gboko Local Government Area of Benue State and Health Implications, North Central Nigeria

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**ABSTRACT----** ***The activity concentrations of some radionuclides in soil samples were collected from10 locations in Gboko local government of Benue State have been determined using the Gamma ray Spectroscopy (Model No: 3M3/3). The soil activity ranges from 58.88 to 64.49Bq/Kg for $^{40}K$, 3.33 to 5.31Bq/Kg for $^{238}U$ and 4.66 to 8.25Bq/Kg for $^{232}Th$ respectively for the urban areas. In the rural areas, the activity concentration ranges from 55.42 to 66.26Bq/Kg for $^{40}K$, 3.77 to 5.55Bq/Kg for $^{238}U$ and 4.21 to 10.02Bq/Kg for $^{232}Th$ respectively. The mean absorbed dose rate in air ranges from 6.78nGy/h in Gboko – East to 9.37nGy/h in Mkar - Hill while the annual effective dose for the same areas varied from 0.01mSv/y in three sites to 0.01mSv/y in Mkar - Hill. The estimated absorbed dose rate in air varied from 6.73nGy/h in BCC to 10.28nGy/h in Gboko – Poly with annual absorbed dose of 0.01mSv/y in BCC to 0.03mSv/y in Ape - Inumbu. The results showed that, the annual effective dose rate is much lower than 0.1mSv/y maximum permissible limit recommended for humans by WHO, (2009). It is also lower than the safe limit of 0.07mSv/y permitted by UNSCEAR,( 2009) for individual members of the public. This reach work indicated that the samples soil may have not been impacted radio logically.***

**Keywords----** Geology, Sample Soil, Gamma spectroscopy, Ionization, Specific Activities, Absorbed dose and Annual effective

## 1. INTRODUCTION

Living things are continuously exposed to natural radionuclides occurring from within and outside the atmosphere. The exposure is due to natural occurring radioactive materials NORM (Ionizing radiation) in the soil, rocks and cosmic rays entering the earth's surface from outer space and the internal exposure from the radioactive elements through food, water and air. The natural terrestrial component is due to decay series of $^{238}U$, $^{232}Th$ and non-series of $^{40}K$ that are present in the environment and this exist in various geological formations (Ajayi *et al.*, 2013).

Measured/estimated exposure to natural radiation from naturally occurring radionuclides has become environmental concern to the public in Nigeria and national authorities of many other countries because of the incomparable health implication caused by these radionuclides. (Tchokossa *et al* 2006., Ajayi *et al* 2009., Diab *et al* 2008., Fatima *et al*., 2008). It has become established that radiation is part of the natural environment and it is estimated that approximately 80% of all human exposure comes from naturally occurring radioactive material (NORM).

To estimate the terrestrial gamma dose rate for outdoor occupation, it is very important to evaluate the natural radioactivity level in soils (Mokobia *et al*., 2000). The knowledge of the distribution and of the behavior of the radionuclides in soil, in particular of the uranium isotopes and its daughter products is essential in understanding several aspects of the natural radiation environment, as the exchange of radionuclides between the soil solid matrix surface and ground surface waters, the uptake of radioactive nuclides by vegetation, the upper soil layers and the atmosphere (Avwiri *et al.*, 2012).

EPA (2005) on environments, health and safety online reported that the more radiation dose a person receives the greater the chance of developing chronic health effect like cancer, heart disease, mutation, hematological depression incidence, eye cataracts, leukemia and chromosome aberrations and death. This may be hidden until many years after the radiation doses are received between (10-40years).

## 2. GEOLOGY

Gboko is northeastern part of lower Benue of trough of Nigeria with a population of over five hundred thousand (500,000) inhabitants basically farmers, the local government are the heart of Tiv nation. The local government is surrounded with sedimentary rocks and the soil dominantly associated with mineral deposits like limestone, gypsum, barite, feldspar, wolf mite, and gemstone. The local government produces about 75% of the Cement supplied in North Central of Nigeria. Yet none of the researchers have done work so far to, addressed the natural radioactivity in soil samples of the area and its health implication on the workers and the general public. The objective of this work therefore, is to measure/estimate the activity concentration of $^{40}K$, $^{238}U$and$^{232}Th$ and also, to create awareness to the public on the health implication of the radionuclides with the aim of assessing the radioactivity level of some surface soil of Gboko local government of Benue State and their associated health impact.

Gboko lies between latitude N7 25 and N8 8 and longitude E9 47 and E10 0 with an average high rain fall of about 1190 – 1792mm annually. Relative humidity is between 43 – 80% and temperature is between $26^0$ and $37^0$C.

Table. Sampling locations and their coordinate.

| Serial No | Location | Latitude/Longitude |
|---|---|---|
| 1 | AOCAY | N7˚8’16”/E8˚37’46” |
| 2 | Ape-inumbu | N7˚46’32”/E8˚53’16” |
| 3 | G. R. A | N7˚48’28”/E9˚54’0” |
| 4 | Fidei-poly | N7˚29’54”/E8˚7’24” |
| 5 | Mkar Hill | N7˚24’3”/E8˚58’1” |
| 6 | Gboko Main Market | N7˚15’27”/E8˚30’43” |
| 7 | Gboko East | N7˚23’34”/E8˚51’2” |
| 8 | Gboko-poly | N7˚33’18”/E8˚0’49” |
| 9 | Gboko Hill | N7˚21’8”/E8˚29’35” |
| 10 | Bcc | N7˚34’13”/E8˚35’47” |

## 3. MATERIAL AND METHOD

### *3.1 Sample Collection*

In order to measure natural radioactivity soil samples were collected from suitable locations that were free of obstructions like buildings, Stones, Trees and not near the road in the sample sites. At a location, the soil samples were collected from the four (4) vertices and the center of 1-2m square land area at a depth of between 0-5cm. The soil samples were processed according to the recommended procedure by the International Atomic Energy Agency. The samples were thoroughly mixed together to form a homogeneous sample of about 400g. The soil samples were packed in labeled plastic containers for analysis preparations.

### *3.2 Sample preparation*

The soil samples were processed according to the recommended procedure by the international Atomic Energy Agency (IAEA) and United Nation for Scientific Committee on Energy and Atomic Radiation (UNSCEAR). They were sun-dried to have a constant weight. They were pulverized and sieved using 2mm mesh to obtain a fine – texture powder that would present a uniform matrix to the detector. About 200g of each sieved soil sample were poured into a plastic container and sealed for at least 30 days before analysis. These allow time for the products to achieved equilibrium with the granddaughters.

### 3.3 *Activity concentration determination*

The activity concentration of $^{40}K$, $^{238}U$ and $^{232}Th$ were measured using gamma ray spectroscopy NaI(TI) method (Model NO. 3M3/3). The detector has a resolution of about 8% at 0.662Mev of 137Cs. The detection energy calibrations of the system was carried out using reference standard source of (IAEA-444) prepared from the Radiochemical Centre, Amersham, England. The 1.460Mev photo peak was used for the measurement of $^{40}K$ while 1.120Mev photo peak from $^{214}Bi$ and the 0.911Mve photo peak from $^{288}Ac$ were used for the measurement of $^{238}U$ and $^{232}Th$, respectively. Each of the samples was counted for 25200 seconds. Absorbed dose and annual effective dose rates were calculated from specific activity concentration. Dose rate in air was estimated using equation (1) and Annual effective dose estimated using equation (2) below:

$D_a$=0.470$A_u$+0.572$A_{Th}$+0.0421$A_k$ (1)

$A_{e(mSv/y)}$ = nGy/h x $O_f$ x 8760 x $C_f$ x $10^{-6}$ (2)

Where $D_a$ is the absorbed dose in air (nGy/h), $A_u$, $A_{Th}$ and $A_k$ are soil specific activity concentrations ($BqKg^{-1}$) and 0.462, 0.621 and 0.0417 are conversions factors in units of nGy$h^{-1}$ per$BqKg^{-1}$. $A_e$ is the annual effective dose (mSv$y^{-1}$), $O_f$ = occupancy factor (0.2 for Urban and 0.3 rural dwellers), $C_f$ = conversion factor (0.7sv$Gy^{-1}$). The gamma-spectroscopy and the Interpolation formulas were used to evaluate the radioactivity of the surface soils, to calculate and predict the health hazards of those radio nuclides implications on humans.

## 4. RESULTS AND DISCUSSION

The results for the activity concentration of natural radionuclides of $^{40}$K, $^{238}$U and $^{232}$Th in soil samples of different locations of some surface soil in Gboko local government of Benue State are reported in Tablle2 and Table3. In Table2 the activity concentration of $^{40}$K ranged from 58.88±0.31Bq/Kg in GRA soil sample to 64.49±042Bq/Kg in Gboko East soil sample, with overall mean of 60.82Bq/Kg. The activity concentration of $^{40}$K is found to be lower in all the sample locations compared with the World Wide Average value of 420Bq/Kg. Also in Table3 the activity concentration of $^{40}$K ranged from 55.42±0.36Bq/Kg in Ape – Inummbu soil sample 66.26±0.41Bq/Kg in Gboko _ Poly soil sample with overall mean of 61.52Bq/Kg. This also shows that, the activity concentration of $^{40}$K is much lower than the world wide average value of 420Bq/Kg. The activity concentration of $^{40}$K in the soils shows the low of presence of granite in soil parent Precambrian metamorphic rock underlying the territory, presence of gypsum and use of phosphate fertilizer by farmers in the areas Ajayi *et al.*, (2012) and UNSCEAR (2009).

The activity concentration of $^{238}$U is ranged from 3.33±0.28Bq/Kg in Gboko East surface soil to 5.31±0.43 in Coll. Of Agric Yandev soil sample, $^{238}$U is found to be low in all the locations of the urban areas with mean concentration of 4.41Bq/Kg. In Table3. The mean activity concentration of $^{238}$U ranged from 3.77±0.31 soil sample of Gboko – Poly to 5.55±0.41 soil sample of Ape – Inummbu. The activity concentration is found to be low in all soil samples in Table3 with mean concentration of 4.45Bq/Kg which much than the World Wide Average value of 33Bq/Kg. This shows low level of $^{238}$U in the soil samples despite the low presence of lead sulphide (Galena), gypsum and different chemical behavior of Thorium and Uranium in soil or parent rocks (UNSCEAR., 2009). The mean activity concentration of $^{232}$Th ranged from 4.66±1.15 in soil sample of Gboko – East to 8.25±1.77Bq/Kg soil sample of Mkar hill with mean activity concentration of 5.82Bq/Kg which is lower than the World Average value of 45Bq/Kg. While in Table3 $^{232}$Th ranged from 4.21±0.10 in soil sample of B.C.C to 10.02±2.14 of Gboko – Poly soil sample, with mean activity of 6.86Bq/Kg. The mean for the study area is much lower than the World Wide Average value of 45Bq/Kg (UNSCEAR., 2000). These result show low activity concentration values in comparison with other parts of the World that have occurred for $^{40}$K, $^{238}$U and $^{232}$Th in the study areas compared to the World Wide Average value of 420, 33 and 45Bq/kg for $^{40}$K, $^{238}$U and $^{232}$Th respectively, (UNSCEAR., 2000). The activity concentration values obtained in this work is lower than the world Wide Average values. Table2 and Table3 show that $^{40}$K accounted for the largest contribution to the total specific activity concentration in all soil samples. This may be as a result of low presence of barites, gypsum, metamorphic rock underlying the territory and low use of phosphate fertilizer by the farmers in the area, Ajayi et al., (2012) and Diab et al., (2008).The absorbed dose rate in air

(nGy/h) at 1.0m average height above the surface of the ground with counting gamma spectroscopy emitter. In Table4.The absorbed dose rate varied from 6.78nGy/h in Gboko – East to 9.37nGy/h in Mkar - hill with a mean concentration of value of 7.91nGy/h. This ranged is found much lower than the ranged 30-70nGy/h of the absorbed dose rate given by UNSCEAR., (2009) and the mean is about triple than the World Wide Average value of 59nGy/h for area of normal background radiation. The mean absorbed rate for rural areas ranged from 6.73nGy/h in B.C.C to 10.28nGy/h in Gboko - Poly with a mean value of 8.59nGy/h. This shows that, the results are lower than the world Wide average value of 59nGy/h (UNSCEAR., 2009), Elena and Grecea., (2004). The annual effective dose equivalent varied from 0.01mSv/y in G.R.A, Gboko Main Market and Gboko – East to 0.01mSv/y in Mkar - hill. The mean annual effective dose equivalent for the whole territory studies is 0.01mSv/y (Urban). This is much lower than the World health organization maximum of value of 0.1mSv/y and World Wide Average value of 0.07mSv/y reported by (UNCEAR., 2009). In rural area the annual effective dose

equivalent ranged from 0.01-0.0.3mSv/y with a mean annual effective dose equivalent of 0.02mSv/y.

Table2. **Specific Gamma ray Activity Concentration of $^{40}$K, $^{238}$U and $^{232}$Th in Urban Areas**.

| **Sites** | $^{40}_{20}K$ | $^{238}_{92}U$ | $^{232}_{90}Th$ | $A_k$ | $A_u$ | $A_{Th}$ |
|---|---|---|---|---|---|---|
| Coll. Of Agric. Yandev | 60.60±0.28 | 5.31±0.43 | 6.32±1.21 | 2.55 | 2.49 | 3.61 |
| GRA Gboko | 58.88±0.31 | 4.82±0.36 | 4.76±1.23 | 2.47 | 2.26 | 2.72 |
| Mkar Hill | 59.21±0.38 | 4.63±0.36 | 8.25±1.77 | 2.49 | 2.17 | 4.71 |
| Gboko Market | 60.94±0.42 | 3.94±0.37 | 5.10±1.11 | 2.56 | 1.85 | 2.91 |
| Gboko-East | 64.49±0.42 | 3.33±0.28 | 4.66±1.15 | 2.56 | 1.56 | 2.66 |
| Range | 58.88-64.49 | 3.33-5.31 | 4.66-8.25 | 2.47-2.56 | 1.56-2.49 | 2.66-4.71 |
| Mean | 60.82 | 4.41 | 5.82 | 2.53 | 2.07 | 3.32 |

Table3. **Specific Gamma ray Activity Concentration of $^{40}$K, $^{238}$U and $^{232}$Th in Rural Areas**

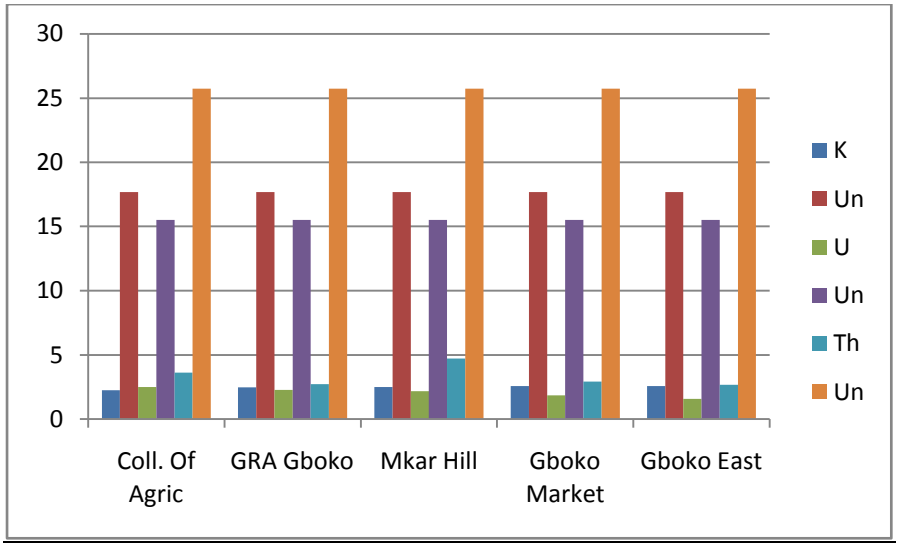
| **Sites** | $^{40}$K | $^{238}$U | $^{232}$Th | $A_K$ | $A_u$ | $A_{Th}$ |
|---|---|---|---|---|---|---|
| Ape-inumbu | 55.42±0.36 | 5.55±0.41 | 6.29±3.49 | 2.33 | 2.61 | 3.59 |
| Fidei-Poly | 64.17±0.28 | 4.78±0.42 | 7.09±1.37 | 2.70 | 2.23 | 4.05 |
| Gboko-Poly | 66.26±0.41 | 3.77±0.31 | 10.02±2.14 | 2.78 | 1.77 | 5.73 |
| Gboko-Hill | 64.86±0.40 | 4.03±0.33 | 6.71±1.55 | 2.73 | 1.89 | 3.83 |
| BCC | 56.87±0.37 | 4.13±0.33 | 4.21±0.10 | 2.39 | 1.94 | 2.40 |
| Range | 55.42-66.26 | 3.77-5.55 | 4.21-10.02 | 2.33-2.78 | 1.77-2.61 | 2.40-5.73 |
| Mean | 61.52 | 4.45 | 6.86 | 2.59 | 2.09 | 3.92 |

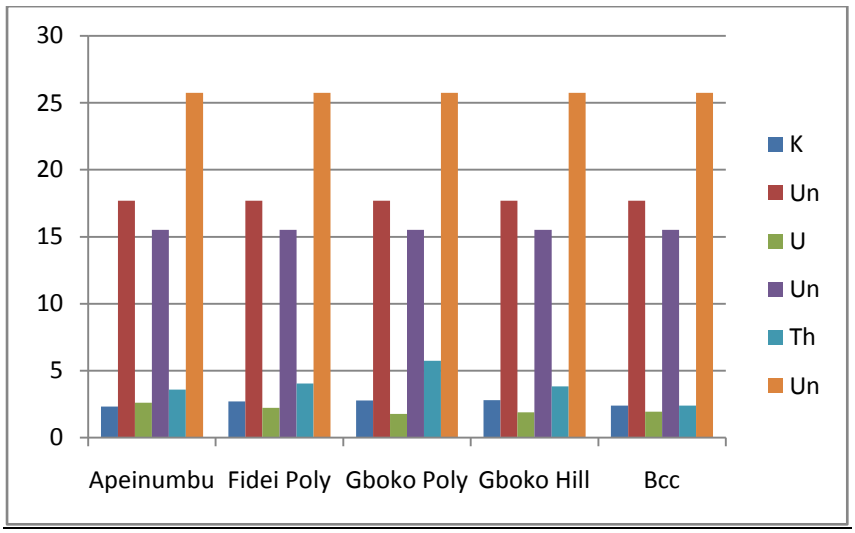
Table4 **Absorbed dose rate and annual outdoor effective dose rate at different sites Areas**

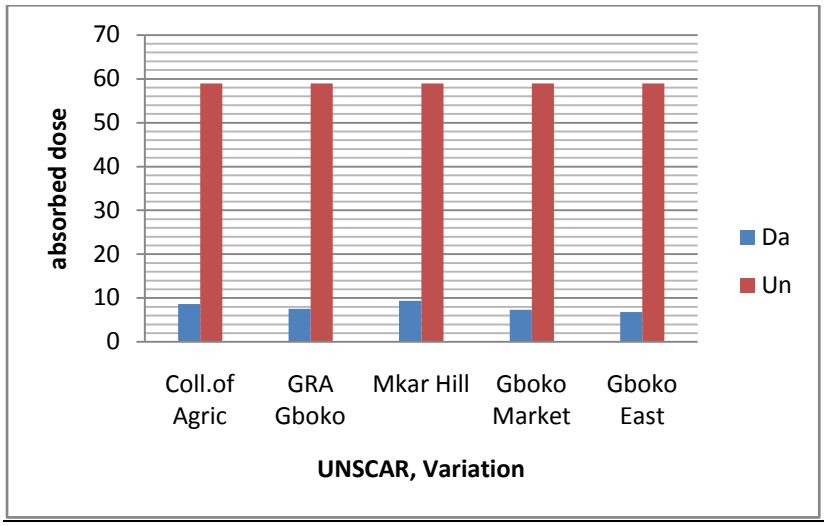
| **Sites** | **Absorbed Dose (nGy/h)** | **Annual Effective Dose (mSv/y)** |
|---|---|---|
| Coll. of Agric Yandev | 8.65 | 0.01 |
| G.R.A | 7.45 | 0.01 |
| Mkar Hill | 9.37 | 0.01 |
| Gboko Market | 7.32 | 0.01 |
| Gboko-East | 6.78 | 0.01 |
| Range | 6.78 – 9.37 | 0.01 – 0.01 |
| Mean | 7.91 | 0.01 |

**Table5: Absorbed dose rate and annual outdoor effective sites areas**

| Sites | Absorbed dose (nGy/h) | annual effective dose(mSy/y) |
|---|---|---|
| Ape-Inumbu | 8.53 | 0.02 |
| Fidei-Poly | 8.98 | 0.02 |
| Gboko-Poly | 10.28 | 0.03 |
| Gboko-Hill | 8.45 | 0.02 |
| B.C.C. | 6.73 | 0.01 |
| Range | 6.73 – 10.28 | 0.01 – 0.03 |
| Mean | 8.59 | 0.02 |

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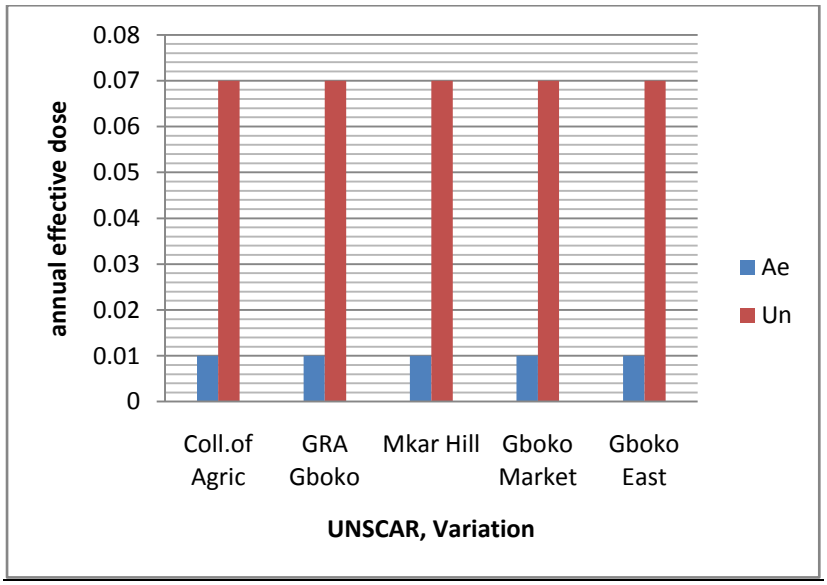
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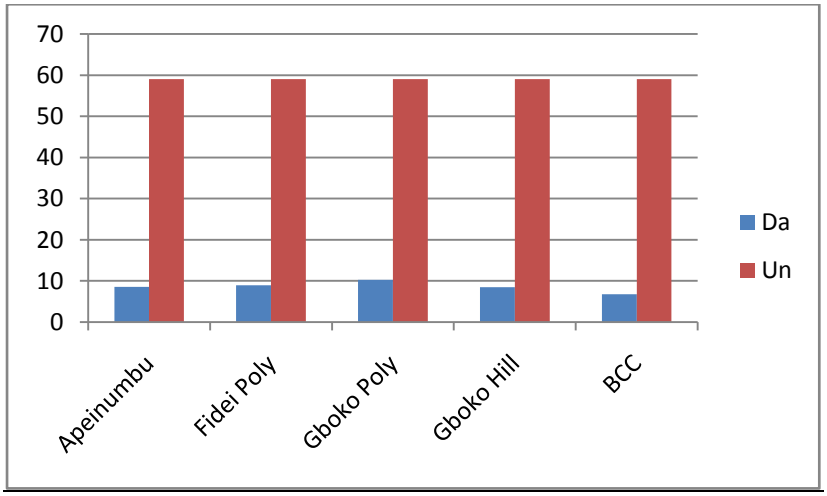
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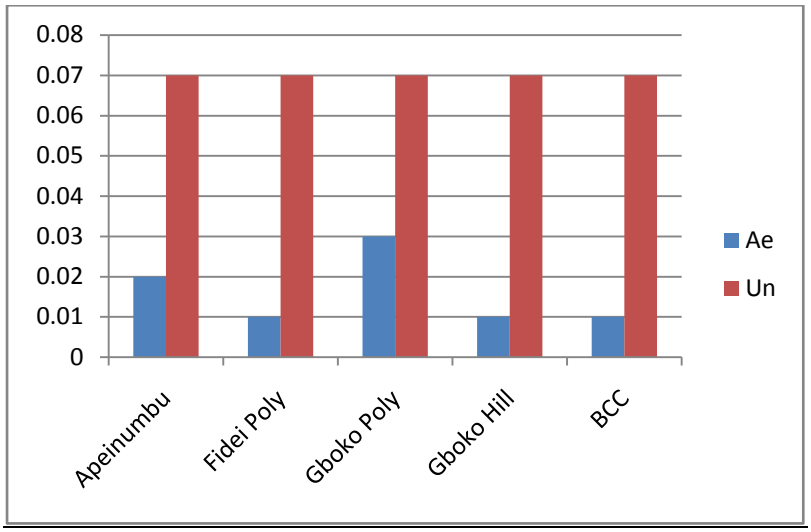


## 5. CONCLUSION

The researched showed that Mkar – Hill and Gboko - Poly sample soils have the highest level of natural radionuclides while B.C.C has the lowest level. The study showed that the health hazards due to natural radionuclides in the sample regions are relatively very low and carried out insignificant radiation implication on the inhabitants.

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