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Radionuclides Content of Some Surface Soils Of Ushongo Local Government Area Of Benue State, North Central, Nigeria.

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Abstract: *Gamma ray spectroscopy (model:3M3/3) was used to analyze soil samples collected from 10 settlements in Ushongo local government area of Benue State, North Central Nigeria. The soil activity concentrations were found to be low in all soil samples with standard deviation value of 27.5, 1.14, and 1.78Bq/kg for ^{40}K, ^{238}U and ^{232}Th; standard mean error of 12.3, 0.51 and 0.79Bq/kg for ^{40}K, ^{238}U and ^{232}Th in urban areas and a standard deviation of 22.5, 1.41 and 2.96Bq/kg for ^{40}K, ^{238}U and ^{232}Th; standard mean error of 10.1, 0.63 and 1.32Bq/kg in rural areas. The mean activity concentration values of 56.20, 4.08, 4.03 in urban areas and mean value of 72.3, 4.89,4.98 in rural areas for ^{40}K, ^{238}U and ^{232}Th respectively. The results of absorbed dose and annual effective dose were lower than the permissible dose reported by (UNSCEAR 2008 and 2009). However, continuous absorption of the radionuclide's may pose health hazards.*

Keywords*: radioactivity, soil, background radiation, evaluation, doses*

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I. Introduction

The radioactivity level from the natural radionuclides is termed as background radiation which depends on the amount of the radioactive materials in the environment. The background radiation can be high if the environment is polluted either from man-made or natural activities. It can also be high in regions with deposit of mineral resources such as uranium ores and phosphate. Materials from the deposit may be brought to the surface soil through processes such as weathering of rocks and soil formation. They can also leach into the groundwater system, contaminate it, and lead to pollution far away from the source (Mohammed and Mazunga., 2013).

Industrial (processing chemicals) and domestic (remnants of staple foods) wastes are known to contain traces of radionuclides. (Ali., 2014). The soil contains different NORMS such as potassium, uranium and Thorium. Jibiri et al., (2007) revealed that, the food consumed in Nigeria contains traces of radionuclide, (Akinloye and Omomo., 2005) also established that vegetation and environmental fields in Nigeria contains traces of radionuclides.

Soil, the upmost part of the earth contains both natural (Primordial, Cosmogenic radionuclides) and manmade radioactive materials which can pass on to the food chain, water and air, contributing to the internal dose received by the population. People are exposed to natural radiation on a daily basis as our planet earth is radioactive. More than75 percent naturally occurring radioactive materials are found in soil, water and air. The natural terrestrial gamma radiation dose rate is an important contributor to the average dose rate received by the world's population (Tso and Leung, 2000) and (UNSCEAR., 1993). Estimation of the radiation dose distribution is important in assessing the health risk to a population and serve as the reference in documenting changes to environmental radioactivity in soil due to anthropogenic activities (Obed, *et al.*, 2005). Human beings are exposed outdoors to the natural terrestrial radiation that originates predominantly from the upper 30 cm of the soil (Chikasawa, *et al.*, 2001). Only radionuclides with half-lives comparable with the age of the earth or their corresponding decay products existing in terrestrial material such as ^{232}Th, ^{238}U and ^{40}K are of great interest. Since these radionuclides are not uniformly distributed, the knowledge of their distribution in soil and rock play an important role in radiation protection and measurement (Rani, and Singh, 2005). Gamma radiation from these represents the main external source of irradiation to the human body and the concentrations of these radionuclides in soil are determined by the radioactivity of the rock and also nature of the process of the formation of the soils (Orabi *et al.*, 2006) and (Al-Jundia *et al.*, 2003). Therefore, radionuclides in soil generate a significant component of the background radiation exposure to the population.

Recent research by Sombo, *et al.*, (2016) reported that the activity concentration of natural occurring radioactive materials (NORM's) in the soil samples of Guma local government area of Benue State ranges from 38.12–58.10Bq/kg, 3.53–4.41Bq/kg, and3.35 –7.11Bq/kg for ^{40}K, ^{238}U and ^{232}Th for urban areas while in the rural areas the concentrations ranged from 54.06 –76.17Bq/kg, 3.66 – 5.27Bq/kg and 4.74 – 7.18Bq/kg ^{40}K, ^{238}U and ^{232}Th respectively. The absorbed dose and annual effective dose range from 5.89 – 7.70nGy/h and 0.01mSv/y in the urban areas with mean of 6.48nGy/h and 0.01mSv/y while in the rural area, the values ranges from 7.48 – 8.52nGy/h and 0.01 – 0.02mSv/y with mean values of 8.00nGy/h and 0.01mSv/y. All the computed values are much lower than permissible value recommended by the United Nation for Scientific Committee on Effect of Atomic Radiation UNSCEAR but lower than the values reported by (Avwiri and Ononugbo., 2012), (Ajayi *et al.,* 2013) and (Dalton *et al.,* 2016). Continuous absorption of radon gas from the decay series of Uranium and Thorium may have imposed high risk of health hazard to man such as, cancer of the lung, hypokalemia, heart disease, mutation, and others hence it becomes very important to investigate the background radiation level in our surface soils.

Research on radioactivity of surface soils in Gboko Local Government Area of Benue State by Ayaakaa, *et al.*, (2016) again reported that the activity concentration of surface soil samples in the area 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, the values were much lower than the values reported by (Avwiri and Ononugbo., 2012), (Ajaiya et al., 2013) and (UNSCEAR., 2009).

Studies by Mohammed and Mazunga., (2013) raveled that the average activity concentrations of soil samples of Mkuju, southern part of Tanzania, shows that ^{238}U(51.7Bq/kg), ^{232}Th (36.4 Bq/kg), and ^{40}K (564.3 Bq/kg) values were higher than the worldwide average concentrations value of these radionuclides reported by (UNSCEAR., 2000).

II. Geology of the study area

Ushongo is located at N7˚13'42" and E8˚10'23". A local government in Benue State, Central Nigeria, has an area of 1,228km^2 with about 0.3million people which is contributed a reasonable population of the State. According 1999, 2006, and 2011 census, the local government had a population density of 123166, 191935 and 223000 people per square kilometer respectively.

The geographical formation of the Ushongo local government is made up of granites, fluoride salt and galena etc. The people here are most farmers.

Table1: Sampling locations and their coordinates in Ushongo local government area.

S/No	Location	Latitude / Longitude
1.	Waapera	N7˚13'42"/E7˚49'30"
2.	Ukari	N7˚50'60"/E9˚46'59"
3.	Waajir	N7˚22'05"/E7˚22'00"
4.	Ugar	N7˚20'55"/E7˚05'55"
5.	Ushongo hill	N7˚44'11"/E9˚8'29"
6.	Lessel Town-ship	N7˚33'49"/E8˚27'16"
7.	Iboko village	N7˚08'13"/E8˚01'00"
8.	Tse-Tsua	N7˚08'51"/E8˚46'00"
9.	Amerami	N7˚00'33"/E8˚10'23"
10.	Agaraga	N7˚3'44"/E8˚8'31"

III. Materials And Methods

3.1 Experimental method

Natural radioactivity of surface soil sample was collected and measured. The soil samples were collected from the four vertices and the centre 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 (IAEA). Samples were collected from 10 (ten) locations see table1, in the local government area using geographical positioning system (GPS) to determine (marked) the exact position of the sampling. The soils were packed into labeled plastic containers for analysis purpose. The samples were, sundried to a constant weight, grind and sieved using 2mm mesh to obtain a fine – powder texture that would give an equilibrium level to the detector. About 200g of each sieved sample was poured into the plastic container and sealed for at least 30 days before analysis. This was to allowed time for the daughters to reunite with their parent radionuclides.

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 were carried out using reference standard source (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 0.911MeV 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) (UNSCEAR, 2008) and with background reduction factor of 12.3, 15.4 and 18.5 for Uranium-238, Thorium-232 and Potassium respectively (Avwiri and Ononugbo., 2012):

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

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

Where

D_a is absorbed dose rate in air (nGy/h), A_u, A_{Th} and A_k are soil specific activity concentration with conversion factors of 0.470, 0.572 and 0.0421 respectively, and A_e is the annual effective dose (mSv/y), O_f is occupancy factor (0.2 for Urban and 0.3 for rural areas), T_y is number of hours in one year (24hx365.25days to take care of leap year), C_f is conversion factor of (0.7mSv/Gy), (UNSCEAR., 2008).

Table2. Activity concentrations of radionuclides (Bq/kg) in soil samples of urban areas.

Location	A_k	A_u	A_{Th}
Ushongo hill	70.94±0.43	3.94±0.32	5.33±0.63
Lessel Town	52.07±0.35	5.42±0.40	2.34±0.68
Waapera	68.39±0.42	3.78±0.31	6.31±1.48
Ukari	79.31±0.41	4.84±0.37	3.88±0.97
Uga	10.24±0.15	2.43±0.23	2.31±0.67
Range	10.24 – 79.31	2.43 - 5.42	2.31 - 6.31
Mean	56.20±0.36	4.08±0.33	4.03±0.88
S.D	27.50±0.13	1.4±0.07	1.78±0.36
SME	12.30±0.06	0.51±0.02	0.79±0.16

S.D = Standard deviation, SME = Standard mean error

Table3. Activity Concentrations of radionuclides (Bq/kg) in soil samples of rural areas.

Location	A_k	A_u	A_{Th}
Waajir	81.31±0.48	3.28±0.28	4.38±1.08
Igboko Villa	85.01±0.51	6.62±0.47	9.76±0.20
Tse-Tsua	97.63±0.57	5.52±0.41	3.79±0.99
Amerami	44.16±0.31	5.44±0.40	5.20±1.24
Ageraga	53.43±0.36	3.60±0.30	1.75±0.57
Range	44.16 – 97.63	3.28 - 6.62	1.75 - 9.76
Mean	72.30±0.45	4.89±0.37	4.98±0.82
S.D	22.50±1.08	1.41±0.07	2.96±0.42
SME	10.10±0.04	0.63 ±0.04	1.32±0.99

S.D = Standard deviation, SME = Standard mean error

Table4. Absorbed dose rate in air and annual outdoor effective dose rate at different locations in the study area due to terrestrial radiation in urban areas.

Sites	Absorbed Dose (nGy/h)	Annual Effective Dose (Ae) (mSv/y)
Ushongo hill	7.87	0.01
Lessel Town	6.06	0.01
Waapera	8.26	0.01
Ukari	7.83	0.01
Uga	2.89	0.004
Range	2.89–8.26	0.004 – 0.01
Mean	6.48	0.01
S.D	2.23	0.0027
S.M.E	0.99	0.0012

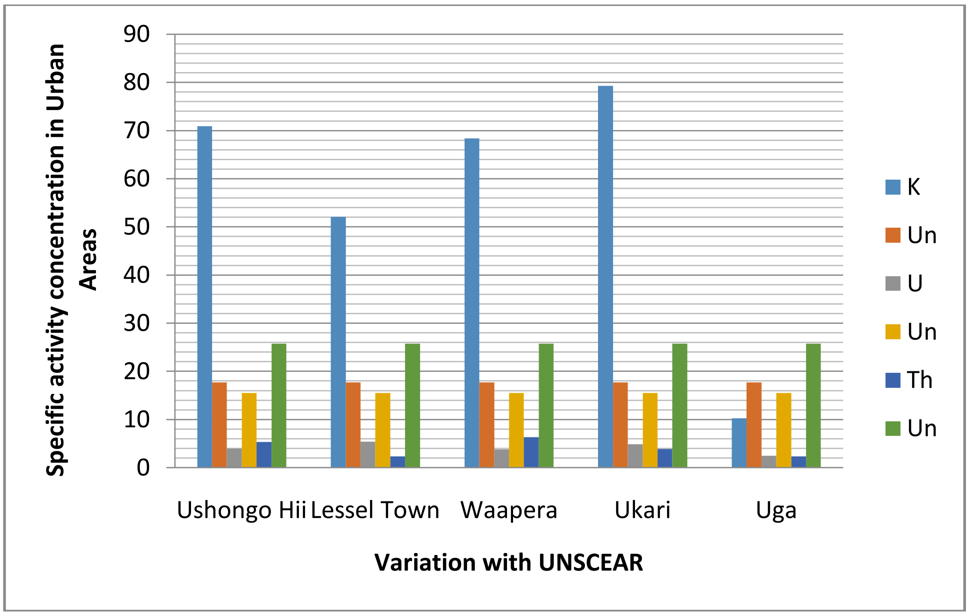
S.D = Standard deviation and S.M.E = Standard Mean Error

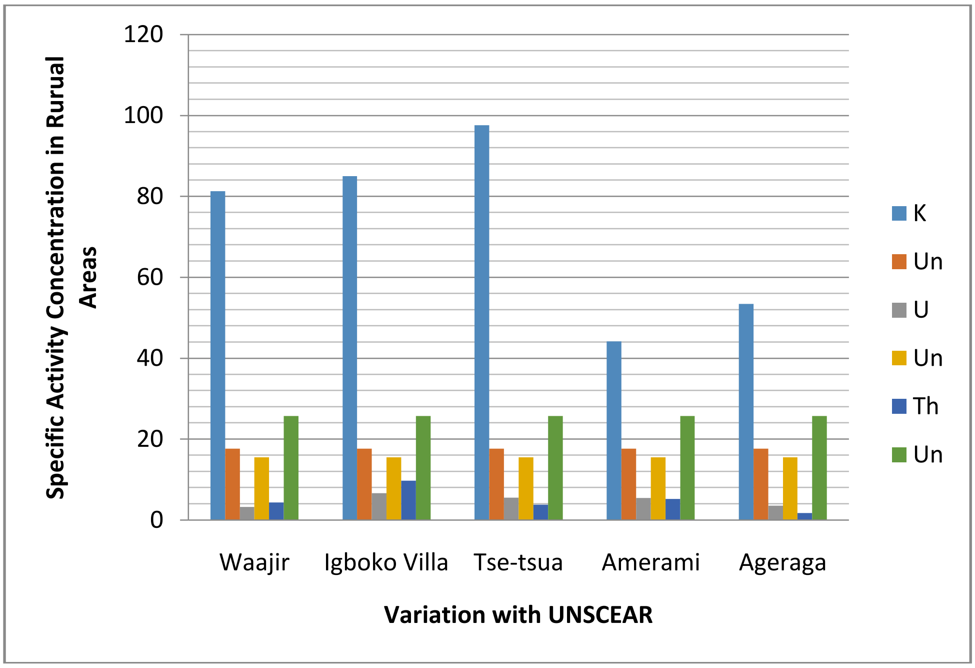
Table5. Absorbed dose rate in air and annual outdoor effective dose rate at different locations in the study area due to terrestrial radiation rural areas.

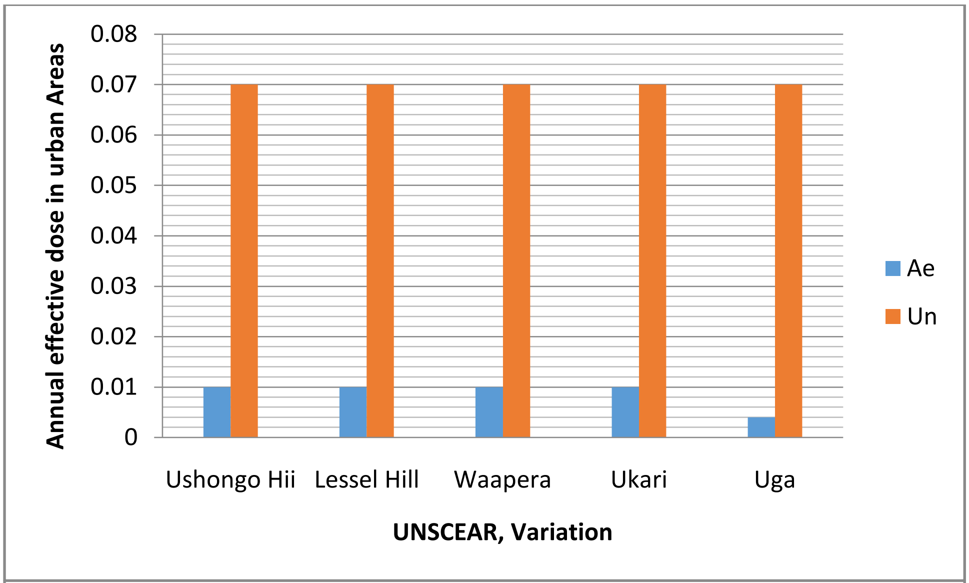
Locations	Absorbed Dose (Da) (nGy/h)	Annual Effective Dose (Ae) (mSv/y)
Waajir	7.47	0.01
Igboko village	12.27	0.02
Tse-Tsua	9.67	0.02
Amerami	7.39	0.01
Ageraga	4.93	0.01
Range	7.48–8.52	0.01 – 0.02
Mean	8.00	0.01
S.D	2.76	0.0055
S.M.E	1.23	0.0025

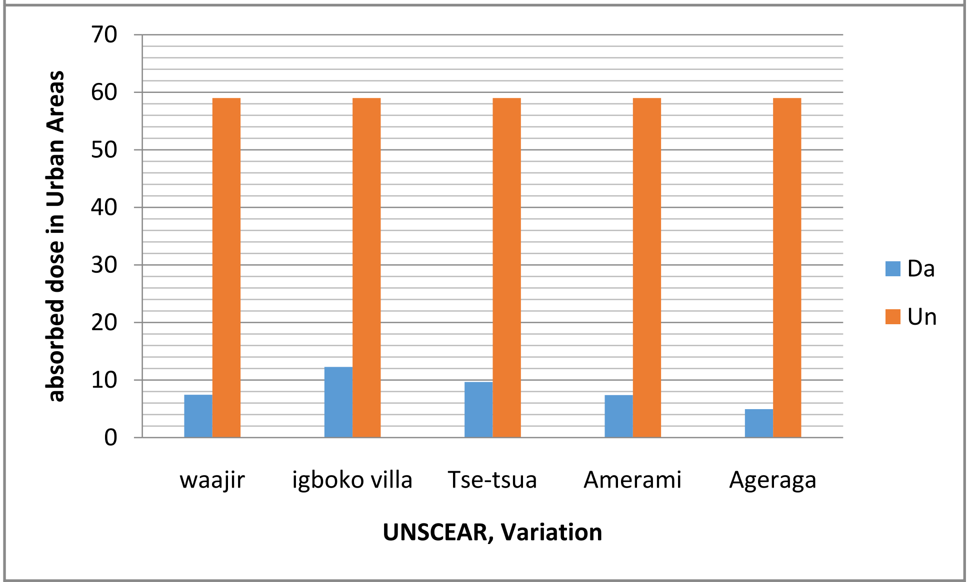
S.D = Standard deviation and S.M.E = Standard Mean Error

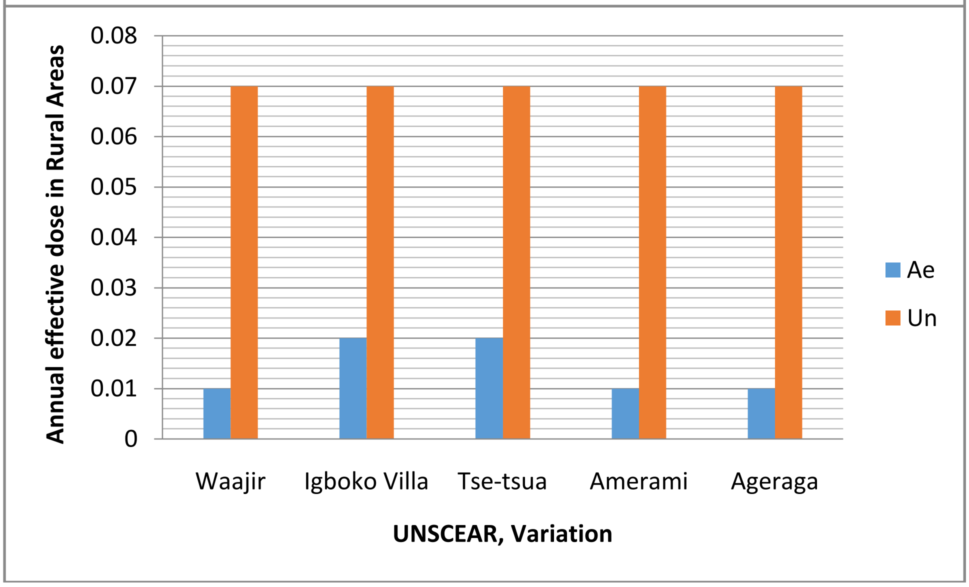
IV. Graphical Charts


Specific activity concentration in Urban Areas
90
80
70
60
50
40
30
20
10
0
Ushongo Hii
Lessel Town
Waapera
Ukari
Uga
Variation with UNSCEAR
K
Un
U
Un
Th
Un


Specific Activity Concentration in Rurual Areas
120
100
80
60
40
20
0
Waajir
Igboko Villa
Tse-tsua
Amerami
Ageraga
Variation with UNSCEAR
K
Un
U
Un
Th
Un


Annual effective dose in urban Areas
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Ushongo Hii
Lessel Hill
Waapera
Ukari
Uga
UNSCEAR, Variation
Ae
Un


absorbed dose in Urban Areas
70
60
50
40
30
20
10
0
waajir
igboko villa
Tse-tsua
Amerami
Ageraga
UNSCEAR, Variation
Da
Un


Annual effective dose in Rural Areas
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Waajir
Igboko Villa
Tse-tsua
Amerami
Ageraga
UNSCEAR, Variation
Ae
Un

V. Results:

The results obtained in this study show the level of radiations emitted by each study given; graphs are plotting to show the level of emission through graphical charts. A radionuclides are unstable atomic nucli that decay spontaneously to emit state that is having one of the tallest hill called Ushongo hill and most of the areas are of rocky formation with multiple colours (dichromic) absorbed radiation them rocks of single colour. The analysis of the background radiation for the specific acting were measured as shown in table 2 and 3 the soil activity ranged from 10.24-79.31 Bg/Kg for A_k, 2.34-5.42 Bk/Kg for A_U and 2.31-6.31 for A_{Th} in urban areas respectively while in rural areas the specific activity ranged from 44.16-97.63 for A_k, 3.28 Au and 1.75-9.76 for A_{Th} with mean 56.20±0.36, standard derivation of 27.5±0.13 and standard mean error of 12.30±0.06 in urban and rural areas mean of 72.30±0.45, 4.89±0.57, 4.98±0.82Bq/kg for A_k, A_u, At_h, standard deviation of 22.50±10.78, 1.41±0.08, 2.96±0.42Bq/kg for A_k, A_u, A_{Th}, respectively. The values reported are 3 times lower than values reported by (Ali., 2013). The values are also much lower than, the world recommendation values of 420Bq/Kg, 33Bq/kg, 45Bg/Kg for $A_{k,}$ A_U and for A_{Th} respectively. Despite the low level of radiation in the soil there are some indices of hazardous indication of some skin diseases affecting most people in the sample areas and this may be of a result of emission of natural radionuclides like ^{40}K, ^{232}U and ^{250}Th radioisotopes associated with rocks (granite). These results show the level of ^{40}K to be higher than ^{232}U and ^{238}Th but are 3 times much lower than the values reported by (Avwiri and Ononugbo., 2012), and (Ajayi and Ibikule., 2013).and 3 times lower than the world wide average walues 420, 33, and 45Bg/Kg for ^{40}K, ^{238}U and ^{238}Th. This little high level of ^{40}K may be as a result of phosphate fertilizer, presence of galena, presence of salt and silica in the soil (Ajayi and Ibikule ., 2013). However the value of ^{40}K are lower than, that of other places in Nigeria and other countries of the world, this could attribute to the types of rock present in the geological formatting of the simple area.(Arwiri and Orwungbo ., 2012).The significant efficiency difference in the urban and rural mean 16.10Bq/kg. This may be as result of the occupancy level of the rural people hence they stay outdoor compared to urban people and also most of the lands and still virgin, this shows that, heavy metals of rationalities exist in rural areas more than urban areas. Hence the rural it areas are having less people and less anstruetum network.

Absorbed dose rate is amount of energy released by lionization emission and absorb by human body. The united nation for scientific committee on effect of Atomic Radiation (UNSCEAR) out alow dose limit for humans as 0.07mSv/y. Table4. reported the absorbed dose (D_a)and annual effective (A_e) in urban areas with standard deviations of 2.23nGy/h and standard mean error of 0.99nGy/h the computed absorbed dose varies from 2.89-8.26nGy/h with the mean value of 6.58nGy/h. The annual effective dose (A_e) values from 0.004-0.01mSv/y with standard deviation of 0.0027mSv/y and mean value of0.0088mSv/y which are far less than the permissible value of 59nGy/h and 0.07mSv/y reported by (UNSCEAR., 2008 and 2009). Table5, Shows the computed absorbed dose and annual effective dose in the rural areas, the absorbed dose varies from 4.93-12.27 nGy/h with standard deviation of 2.76nGy/h, standard mean error of 1.23nGy/h and mean of 8.35nGy/h while the annual effective dose (A_e) ranges from 0.01-0.02mSv/y with mean value of 0.014nGy/h, standard deviation of 0.0055mSv/y and standard mean error of 0.0025mSv/y the values are 3 times lower than the permission dose approved by UNSCEAR. But continuous inhalation may result to health implications such as high & low blood pressure, hypokalemia, antibiotics, heart diseases, cancer of the lungs and others. This calls for medical investigation of the areas sampled.

VI. Conclusion

The assessment of radioactivity of 10 surface soils sample of Ushongo local government of Benue State, Central Nigeria has been carried out using NaI (TI) detector. The specific activity concentration in all the soil samples are much lower than the normal background radiation of 59nGy/h and the computed absorbed dose rate results are also lower than the permissible safe limit recommended by the (UNSCEAR., 2008). The reported values may not indicate immediate health implications but continuous absorption may lead to a long term health problem (Ayaakaa, *et al.,* 2016).

Recommendations

Having done the radiological investigation of the sample soils we are calling for the medical investigation of prevailing ailments in the sample areas hence continuous absorption may lead to serious health impact (hazard)

- Regular checking of radiation impact emission level is recommended in order to keep the health record.
- Government should inform the people in the villages the need for wearing cloth hence most people walk for a long distance bare chest.

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