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Evaluation of Natural Radionuclides in Selected Dumpsites in Gboko, Makurdi and Otukpo Towns of Benue State North Central Nigeria

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ABSTRACT

The activity concentrations of some radionuclides in dumpsites samples were collected from 8selected locations in Gboko, selected locations each in Makurdi and Otukpo metropolis respectively of Benue State have been determined using the Gamma ray Spectroscopy (model T35240K). The soil activity from Gboko ranges from 13.10±0.25 Bq/Kg to 22.56±0.32 Bq/Kg for ^{40}K, 0.35±0.00 Bq/Kg to 0.71±0.00 Bq/Kg for ^{238}U and 0.12±0.00 Bq/Kg to 1.20±0.00 Bq/Kg for 232Th respectively with mean value of 19.15±0.29Bq/Kg for ^{40}K, with the mean value of 0.60±0.00 Bq/Kg for ^{238}U, and with the mean value of 0.14±0.00Bq/Kg for ^{232}Th respectively in Gboko. The soil activity from Makurdi ranges from 12.88±0.24 Bq/Kg to 22.23±0.32 Bq/Kg for ^{40}K, 0.37±0.00 Bq/Kg to 0.66±0.00 Bq/Kg for ^{238}U and 0.09±0.00 Bq/Kg to 0.21±0.00 Bq/Kg for ^{232}Th respectively with the mean value of 18.76±0.29Bq/Kg for ^{40}K, mean value of 0.52±0.00 Bq/Kg for^{238}U and with mean value of 0.15±0.00 Bq/Kg for ^{232}Th respectively in Makurdi. The soil activity from Otukpo ranges from 10.42±0.22 Bq/Kg to 23.59±0.33 Bq/Kg for ^{40}K, 0.41±0.00 Bq/Kg to 0.68±0.00 Bq/Kg for ^{238}U and 0.14±0.00 Bq/Kg to 0.20±0.00 Bq/Kg for ^{232}Th with the mean value of 17.86±0.36 Bq/Kg for ^{40}K, with the mean value of 0.54±0.00 Bq/Kg for ^{238}U and with the mean value of 0.17±0.00 Bq/Kg for ^{232}Th respectively in Otukpo. The mean absorbed dose rate in air from Gboko ranges from 0.91±0.00 nGyhr $^{-1}$ to 1.35±0.00 nGyhr $^{-1}$, the mean absorbed dose rate in air from Makurdi ranges from 0.80±0.00 nGyhr $^{-1}$ to 1.17±0.00nGyhr $^{-1}$and the mean absorbed dose rate in air from Otukpo ranges from 0.74±0.00nGyhr $^{-1}$ to 1.28±0.00nGyhr $^{-1}$while the annual effective dose for Gboko varied from 0.0011±0.00 mSvy $^{-1}$ to 0.0016±0.00 mSvy $^{-1}$, the annual effective dose for Makurdi varied from 0.0009±0.00 mSvy $^{-1}$ to 0.0016±0.00 mSvy $^{-1}$ and for Otukpo varied from 0.0009±0.00mSvy $^{-1}$ to 0.0015±0.00 mSvy $^{-1}$.The results showed that, dose rate are lower than the safe limit of 0.07mSv/y permitted by UNSCEAR for individual members of the public. This reach work indicated that the samples soil may have not been impacted with high radiological risk.

Keywords:
Radionuclides,
Dumpsites,
Benue State.

INTRODUCTION

The Earth is naturally radioactive, and about 90% of human radiation exposure arises from natural sources such as cosmic radiation, exposure to radon gas and terrestrial radionuclides (WHO 2016). However, it has been observed that the type and concentration vary considerably depending on the soil type. The effects of the radiation emitted by different radionuclides depend on the over lining soil material (thickness and type), its chelating agents and physio-chemical properties (Believermis et al., 2009). Investigation has shown that natural radioactivity and the associated exposure due to gamma radiation (i.e. from radionuclides) depend primarily on geology. Refuse dumps can be regarded as primary sources of environmental health hazards to the general public in major cities of the world. Besides the offensive odour that emanates from them, there are radiation emissions that can be detrimental to health (Ojoawo, 2011).Human activities have always generated waste. In Nigeria with a population of over 140 million people (National Population Commission, 2006) waste is still a problem with several challenges to be addressed. It is a common practice that inhabitants in the urban areas tend to dump refuse (wastes) as if it has no implications on their community health and social welfare. Studies have shown that thousands of lives are

lost every year due to environmental related diseases such as cholera, diarrhea, malaria fever, typhoid fever, fever blindness, (Onu and Opara, 2001).

Land filling is one of the most common methods of waste disposal globally (Taylor, 2003). As much as this is an alternative to waste management, it still poses environmental hazards in varying degrees based on its location from residential areas. Indiscriminate and arbitrary waste dumping is still a problem faced in most developing countries. This may pose a health risk to the population as this can have effects on the soil and underground water by way of pollution which can also lead to land degradation (Odunaike etal., 2008). Dumpsites constituents are not only environmental and public nuisance but, also serve as a source of radiation due to the accumulation of radionuclides in them (Olubosede, Akinnagbe, Adekoya 2012). The disposal of waste indiscriminately exposes the environment and its inhabitants to different forms of hazards such as, sunlight, radio waves, x-ray, heat, alpha, beta and gamma ionizing radiation. Presence of disease causing organisms and odour are not the only hazard posed by waste dumpsites, they can result in radiation emanating from these dumpsites. Then, it becomes necessary to evaluate some dumpsites in the state.

Study Areas

Gboko town is one among the major town in Benue state, it is located at latitude: 7.3368º N longitude: 9.0018º E north central Nigeria. Makurdi is the state capital of Benue state, Nigeria. Located at latitude 7.7338º N Longitude 8.5214º E North central of the country, while Oturkpo is also a major town in Benue state located at latitude7.1982º N longitude 8.1393º E North Central Nigeria. These mentioned towns are among the highest populated towns in Benue state, as such the level of activities in these areas are highly intensive which call for concern over state of people dwelling in such areas, to safe lives in the following towns, this research is require because the higher the populations, the higher the waste product due to usage.

MATERIALS AND METHOD

Absorbed dose

The amount of energy absorbed by irradiated matter per unit mass. This reflects the amount of energy deposited by ionizing radiation as it passes through a medium (such as air, water or living tissue). When ionizing radiation penetrates the human body or an object, it deposits energy. The energy absorbed from exposure to radiation is called an absorbed dose. The absorbed dose is measured in a unit called the gray (Gy). A dose of one gray is equivalent to a unit of energy (joule) deposited in a kilogram of a substance (Nick, 2019).

Equivalent dose rate

Equivalent dose (H_T) is a dose quantity calculated for individual organs (index T – tissue). Equivalent dose is based on the absorbed dose to an organ, adjusted to account for the effectiveness of the type of radiation. Equivalent dose is given the symbol H_T. The SI unit of H_T is the sievert (Sv). To obtain the equivalent dose, the absorbed dose is multiplied by a specified radiation weighting factor (w_R). A radiation weighting factor (w_R) is use to equate different types of radiation with different biological effectiveness. The equivalent dose is expressed in a measure called the sievert (Sv). This means that 1 Sv of alpha radiation will have the same biological effect as 1 Sv of beta radiation (Nick, 2019).

Measurements was carried out at the study areas, values of radiations was read from the Inspector Alert Meter to identify high radiation spots at the dumpsite where samples were obtained, the various radiation values corresponding to distance (0 cm to 5 cm) was obtained using the measuring tape at different locations round the circumference of the dumpsite. The meter was placed at a height of 1.5 m above the ground in each case. At a spot where high radiation value is read, the soil sample were collected about 0 - 5 cm depth from the soil surface, the soil samples were collected in plastic containers and well labeled to avoid mix up. Thereafter the soil samples were sundried and sieved using mesh of 2mm in order to remove unwanted elements (like; pieces of stones, gravel and lumps) to have a fine powder texture of the soil samples. The samples was properly sealed and stored for 30days before analysis. This was to let short lived progenies to reach secular radioactive equilibrium before gamma counting.

Analytical Method

The soil samples were analyzed using a sodium iodide machine Canberra MP2-2U with serial no.13040030 model T35240K.The counting time for each of the samples was set at 21, 600 seconds (seven (7) hours). Individual radionuclides were identified by their gamma energies.

Measurement of radioactivity of gamma-ray emitting nuclei was conducted depending on the high penetration power of gamma rays using sodium iodide NaI(Tl) detector system, this system equipped with multi-channel analyzer (MCA) which contains channels connected to Analog to Digital Convertor that helps the analyzer to convert the next pulse into digital numbers. The radiation measurements and their analysis were conducted using a computer program.

RESULTS AND DISCUSSION

The activity concentrations of$^{235}_{U}$, $^{232}_{Th}$ and $^{40}_{K}$ resultsis determined in the soil samples collected from selected dumpsites in Makurdi, Gboko and Otukpo towns in Benue State, North Central, Nigeria shown in 1, 2 &3 respectively.

Table 1: Activity concentration of Radionuclide in$Bqkg^{-1}$ Gboko Dumpsites.

Location	40_K	235_U	232_{Th}	$D_R(nGyhr^{-1})$	$D_e(mSvy^{-1})$
Gboko south	20.19±0.31	0.54±0.00	0.12±0.0	0.15	0.0014
Mkar	22.00±0.32	0.35±0.00	0.16±0.00	1.18	0.0014
Adekaa	13.10±0.25	0.56±0.00	0.17±0.00	0.91	0.0011
G.R.A	19.09±0.30	0.62±0.00	0.13±0.00	1.16	0.0014
Hausa quarters	17.43±0.28	0.71±0.00	0.17±0.00	1.16	0.0014
New road	22.56±0.32	0.67±0.00	0.15±0.00	1.35	0.0016
Akaajime	19.58±0.30	0.66±0.00	0.16±0.00	1.22	0.0014
Rice mill	19.25±0.30	0.70±0.00	1.20±0.00	1.20	0.0014
Mean	19.15±0.29	0.60±0.00	0.14±0.00	1.16	0.0013
Rang	13.10±0.25-22.56±0.32	0.35±0.00-0.67±0.00	0.12±0.00-1.20±0.00	0.91-1.35	0.0011-0.0014
Standard deviation	2.74±0.00	0.26±0.00	0.36±0.00	0.1±0.00	0.0000±0.0000
Standard error	0.97±0.00	0.09±0.00	0.12±0.00	0.03±0.00	0.0000±0.0000

Table 2: Activity concentration of Radionuclide in$Bqkg^{-1}$ Makurdi Dumpsites

Location	40_K	235_U	$232_{Th}D_R(nGyhr^{-1})D_e(mSvy^{-1})$		
Achusa	12.88±0.24	0.46±0.00	0.09±0.00	0.80	0.0009
Gyado villa	19.48±0.30	0.48±0.00	0.10±0.00	1.10	0.0013
Wadata market	18.78±0.30	0.62±0.00	1.17±0.00	1.17	0.0014
Modern market	18.36±0.29	0.58±0.00	0.21±0.00	1.16	0.0014
Naka road	19.91±0.30	0.37±0.00	0.21±0.00	1.12	0.0013
Judges quarters	22.23±0.32	0.66±0.00	0.16±0.00	1.33	0.0016
Mechanic village Kanshio	19.72±0.30	0.48±0.00	0.18±0.00	1.15	0.0014
Mean	18.76±0.29	0.52±0.00	0.15±0.00	1.11	0.0013
Rang	12.88±0.24-22.23±0.32	0.37±0.00-0.66±0.00	0.09±0.00-0.21±0.00	0.80-1.17	0.0009-0.0016
Standard deviation	2.65±0.00	0.00±0.00	0.37±0.00	0.14±0.00	0.0000±0.0000
Standard error	1.00±0.00	0.00±0.00	0.14±0.00	0.05±0.00	0.0000±0.0000

Table 3: Activity concentration of Radionuclide in$Bqkg^{-1}$ Otukpo Dumpsites.a

Location	40_K	235_U	$232_{Th}D_R(nGyhr^{-1})D_e(mSvy^{-1})$		
AnmodaOglewu	23.59±0.33	0.41±0.00	0.17±0.00	1.28	0.0015
Enugu road	19.27±0.30	0.48±0.00	0.16±0.00	1.12	0.0013
United road	10.42±0.22	0.44±0.00	0.17±0.00	0.74	0.0009
General Hospital	12.04±0.24	0.68±0.00	0.18±0.00	0.92	0.0011
Sabon gari	19.39±0.30	0.64±0.00	0.20±0.00	1.23	0.0015
Ella market	20.76±0.83	0.58±0.00	0.17±0.00	1.24	0.0015
Railway	19.56±0.30	0.61±0.00	0.14±0.00	1.19	0.0014
Mean	17.86±0.36	0.54±0.00	0.17±0.00	1.10	0.0013
Rang	10.42±0.22-23.59±0.33	0.41±0.00-0.68±0.00	0.14±0.00-0.20±0.00	0.74-1.28	0.0009-0.0015
Standard deviation	5.53±0.57	0.18±0.00	0.02±0.00	0.38±0.00	0.0005±0.0000
Standard error	2.09±0.28	0.07±0.00	0.00±0.00	0.14±0.00	0.0002±0.0000

Discussion

The activity concentrations in soil samples from selected dumpsites in Gboko shows that, the value of ^{40}K ranged from 13.10±0.25 Bq/Kg in Adekaa soil sample to 22.56±0.32 Bq/Kg in New road soil sample, with overall mean of 19.15±0.29 Bq/Kg, the activity concentration of ^{40}K in Gboko is found to be lower in all the sample locations compared with the World Wide Average value of 420 Bq/Kg reported by UNSCEAR (2009) and lower than the values reported by (Ayaakaa *et al.,* 2016). The activity concentrations in soil samples from selected dumpsites in Gboko shows that, the value of ^{235}U ranged from 0.35±0.00 Bq/Kg in Mkar soil sample to 0.71±0.00 Bq/Kg in Hausa quarters soil sample, with overall mean of 0.60±0.00 Bq/Kg, the activity concentration of ^{235}U in Gboko is found to be lower in all the sample locations compared with the World Wide Average value 35 Bq/Kg of ^{235}U reported by UNSCEAR (2009), The activity concentrations in soil samples from selected dumpsites in Gboko shows that, the value of ^{232}Th ranged from 0.12±0.00 Bq/Kg in Gboko south soil sample to 1.20±0.00 Bq/Kg in Rice

mill soil sample, with overall mean of 0.14±0.00 Bq/Kg, the activity concentration of ^{232}Th in Gboko is found to be lower in all the sample locations compared with the World Wide Average value 45 Bq/Kg of ^{232}Th reported by UNSCEAR (2009) and much lower than the values reported by (Sombo, 2018).

Similarly the activity concentrations in soil samples from selected dumpsites in Makurdi shows that, the value of ^{40}K ranged from 12.88±0.24 Bq/Kg in Achusa soil sample to 22.23±0.32 Bq/Kg in Judges quarters soil sample, with overall mean of 18.76±0.29 Bq/Kg therefore The activity concentration of ^{40}K in Makurdi is found to be lower in all the sample locations compared with the the values reported by (Sombo, 2018) and the World Wide Average value of 420 Bq/Kg reported by UNSCEAR (2009), the activity concentrations in soil samples from selected dumpsites in Makurdi shows that, the activity concentration value of ^{235}U ranged from 0.37±0.00 Bq/Kg in Naka road soil sample to 0.66±0.00Bq/Kg in Judges quarters soil sample, with overall mean of 0.52±0.00 Bq/Kg, the activity concentration of ^{235}U in Makurdi is found to be lower in all the sample locations compared with the World Wide Average value 35 Bq/Kg of ^{235}U reported by UNSCEAR (2009), the activity concentrations in soil samples from selected dumpsites in Makurdi shows that, the value of ^{232}Th ranged from 0.09±0.00 Bq/Kg in Achusa soil sample to 0.21±0.00 Bq/Kg in Modern market soil sample, with overall mean of 0.15±0.00 Bq/Kg, the activity concentration of ^{232}Th in Makurdi is found to be lower in all the sample locations compared with the World Wide Average value 45 Bq/Kg of ^{232}Th reported by UNSCEAR (2009) and much lower than the values reported by (Avwiri and Olatubosun, 2014).

Also the activity concentrations in soil samples from selected dumpsites in Otukpo shows that, the value of ^{40}K ranged from 10.42±0.22 Bq/Kg in united road soil sample to 23.59±0.33 Bq/Kg in Anmoda Oglewu soil sample, with overall mean of 17.86±0.36Bq/Kg. The activity concentration of ^{40}K in Otukpo is found to be lower in all the sample locations compared with the World Wide Average value of 420 Bq/Kg reported by UNSCEAR (2009), the activity concentrations in soil samples from selected dumpsites in Otukpo shows that, the value of ^{235}U ranged from 0.41±0.00 Bq/Kg in Anmoda Oglewu soil sample to 0.68±0.00 Bq/Kg in General Hospital soil sample, with overall mean of 0.54±0.00 Bq/Kg. The activity concentration of ^{235}U is found to be lower in all the sample locations compared with the World Wide Average value 35 Bq/Kg of ^{235}U reported by UNSCEAR (2009) and much lower than the values reported by (Adeola, 2021), the activity concentrations in soil samples from selected dumpsites in Otukpo shows that, the value of ^{232}Th ranged from 0.14±0.00 Bq/Kg in Railway soil sample to 0.20±0.00 Bq/Kg in Sabon gari soil sample, with overall mean of 0.18±0.00 Bq/Kg, the activity concentration of ^{232}Th in Otukpo is found to be lower in all the sample locations compared with the World Wide Average value 45 Bq/Kg of ^{232}Th reported by UNSCEAR (2009) and lower than the values reported by (Bello 2015).

Absorb Dose

The result of the absorbed dose were also calculated from the samples collected from Gboko which, the value ranged from 0.91±0.00nGyhr^{-1} in Adekaa soil sample to 1.35±0.00nGyhr^{-1}in New road soil sample, which is lower than the values reported by (Bello, 205) and much lower than the recommended UNSCEAR safe value of 59 nGyhr^{-1} reported in (2009) with the mean value of 1.16±0.00nGyhr^{-1} and standard deviation of 0.1±0.00nGyhr^{-1} with the highest value of 1.35 nGyhr^{-1} in new road, this shows that the people living in the area are safe but continuous intake of the dose may lead to serious health hazard.

Similarly the result of the absorbed dose were also calculated from the samples collected from Makurdi which, the value ranged from 0.80±0.00 nGyhr^{-1}in Achusa soil sample to 1.17±0.00nGyhr^{-1}in Wadata soil sample, which is lower than the recommended UNSCEAR safe value of 59nGyhr^{-1} reported in (2009) with the mean value of 1.11nGyhr^{-1} and standard deviation of 0.14 nGyhr^{-1} with the highest value of 1.33nGyhr^{-1} inJudges quarters which are much lower than the values reported by (Adeola, 2021), this shows that the people living in the area are safe but continuous intake of the dose may also lead to serious health hazard.

Also calculated from the samples collected from Otukpo which, the value ranged from 0.74±0.00nGyhr^{-1}in united road soil sample to 1.28±0.00nGyhr^{-1}in Anmoda Oglewu soil sample, which is lower than the recommended UNSCEAR safe value of 59nGyhr^{-1} reported in (2009) with the mean value of 1.10 nGyhr^{-1} and standard deviation of 0.38nGyhr^{-1} with the highest value of 1.28nGyhr^{-1} in Anmoda Oglewu, this shows that the people living in the area are safe but continuous absorption of the dose may also lead to health hazard.

Annual Effective Dose

The result of the annual effective dose were also calculated from the samples collected from Gboko which, the value ranged from 0.0011±0.00mSvy^{-1} in Adekaa soil sample to 0.0016±0.00 mSvy^{-1}in New road soil sample, which is lower than the recommended UNSCEAR safe value of 0.07 mSvy^{-1} reported in (2009) with the mean value of 0.0013nGyhr^{-1} and standard deviation of 0.00 nGyhr^{-1} with the highest value of 0.0016 nGyhr^{-1} in new road, this shows that

the people living in the area are safe but continuous absorption of the dose may lead to health treat.

Similarly the result of the annual effective dose were also calculated from the samples collected from Makurdi which, the value ranged from $0.0009\pm0.00 m\text{Svy}^{-1}$in Achusa soil sample to $0.0016\pm0.00 m\text{Svy}^{-1}$in Judges quarters soil sample, which is lower than the recommended UNSCEAR safe value of $0.07 m\text{Svy}^{-1}$ reported in (2009) with the mean value of $0.0013 n\text{Gyhr}^{-1}$ and standard deviation of $0.00 n\text{Gyhr}^{-1}$ with the highest value of $0.0016 n\text{Gyhr}^{-1}$ in Judges Quarters, this shows that the people living in the area are safe but continuous absorption of the dose may lead to health treat.

The result of the annual effective dose were also calculated from the samples collected from Otukpo which, the value ranged from $0.0009\pm0.00 m\text{Svy}^{-1}$in United road soil sample to $0.0015\pm0.00 m\text{Svy}^{-1}$in Ella market soil sample, which is lower than the recommended UNSCEAR safe value of $0.07\ m\text{Svy}^{-1}$ reported in (2009) with the mean value of $0.0013 n\text{Gyhr}^{-1}$ and standard deviation of $0.0005 n\text{Gyhr}^{-1}$ with the highest value of $0.0016 n\text{Gyhr}^{-1}$ in Ella market,Sabon Gari and Anmoda Oglewu, this shows that the people living in these areas are safe but continuous absorption of the dose will lead to health challenge.

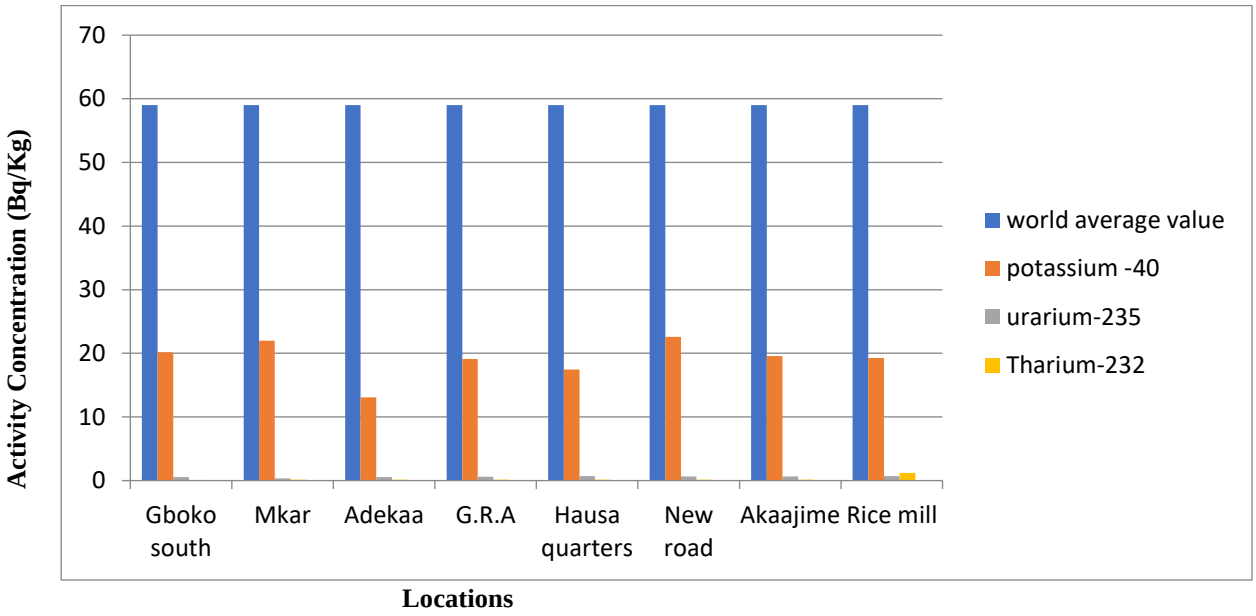

Plate 1: Chart Interpretation of Results of ^{40}K, ^{235}U and ^{232}Th in Gboko Town Dumpsite

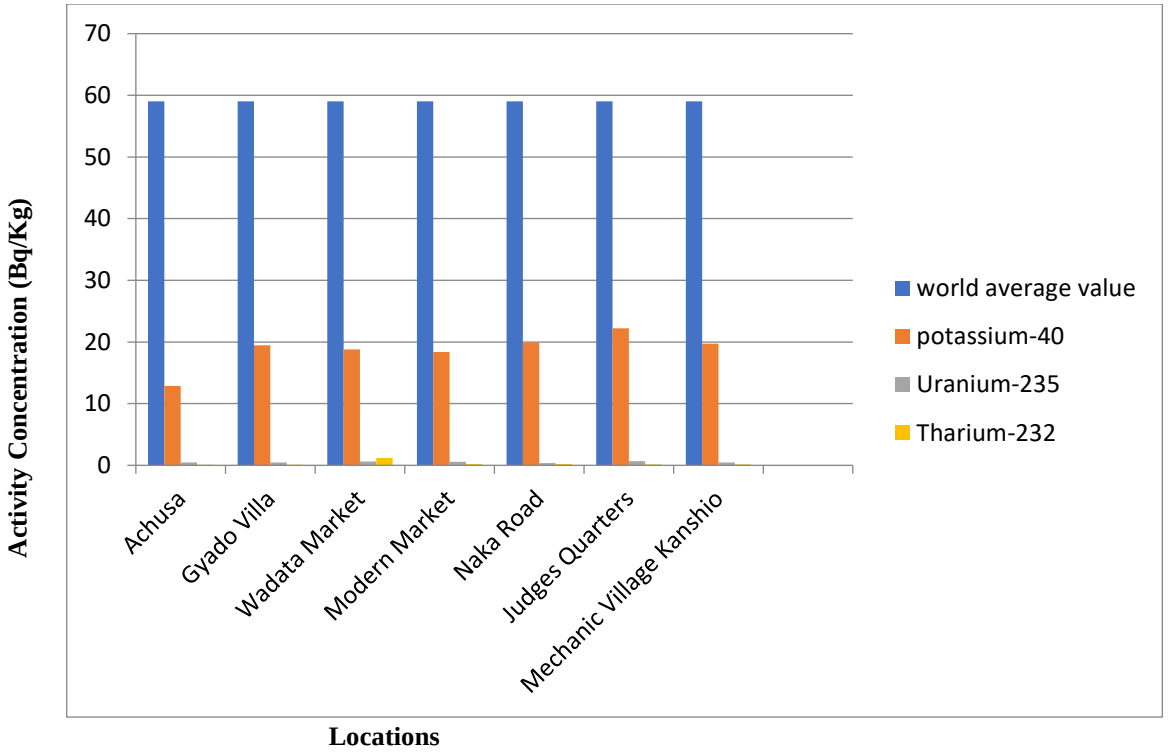

Plate 2: Chart Interpretation of Results of ^{40}K, ^{235}U and ^{232}Th in Makurdi Town Dumpsites

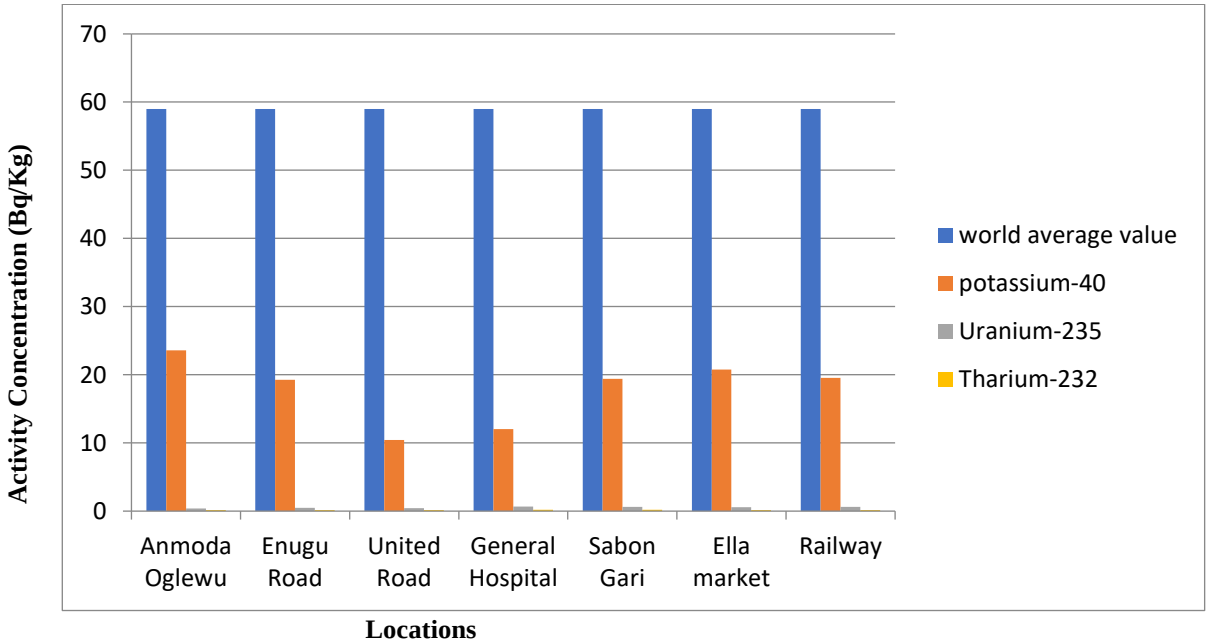

Plate 3: Chart Interpretation of Results of ^{40}K, ^{235}U and ^{232}Th in Otukpo Town Dumpsites

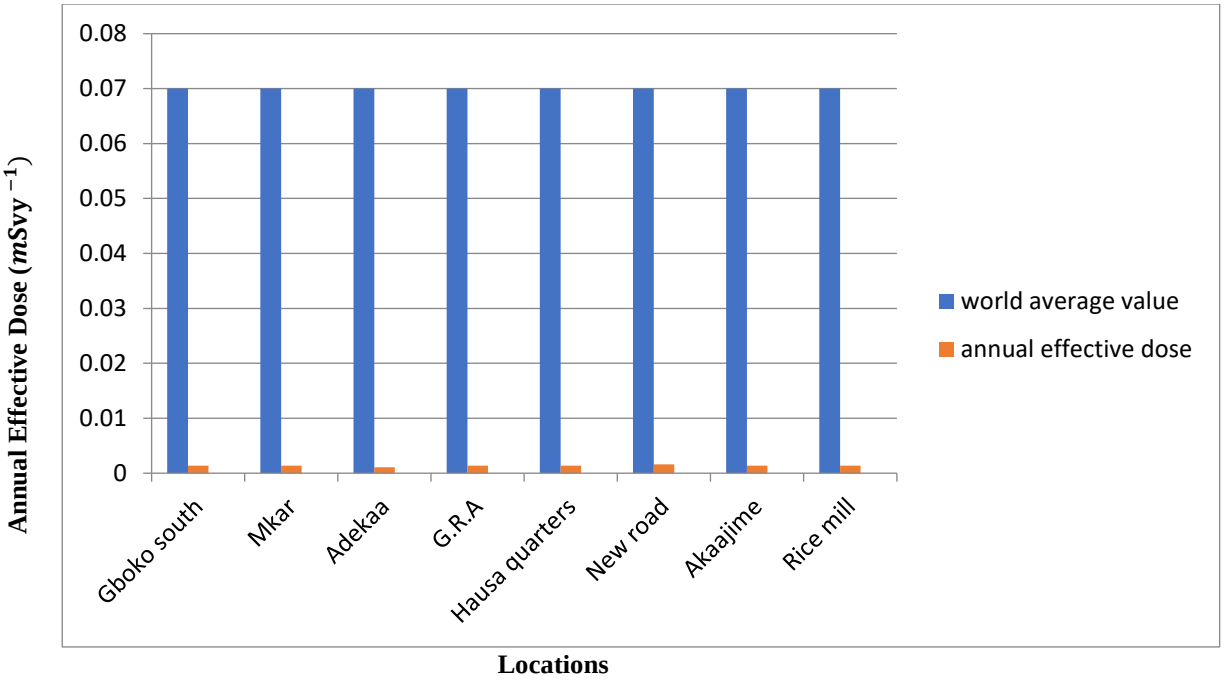

Plate 4: Chart Interpretation of Results of Annual Effective Dose in Gboko Town Dumpsites

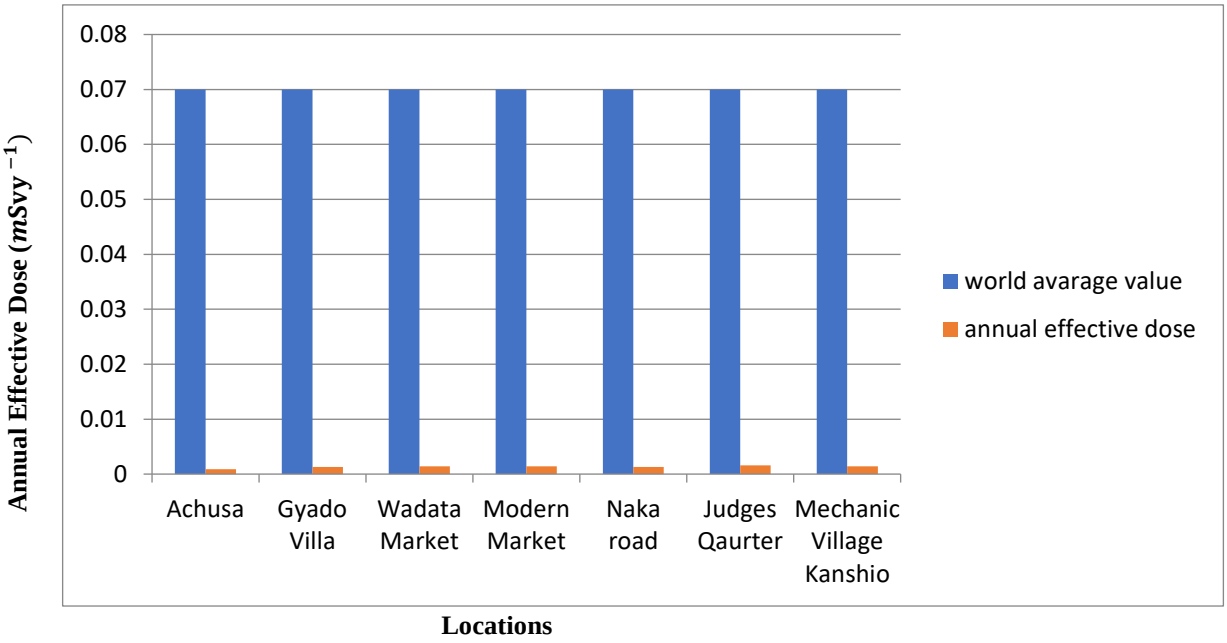

Plate 5: Chart Interpretation of Results of Annual Effective Dose in Makurdi Town Dumpsites

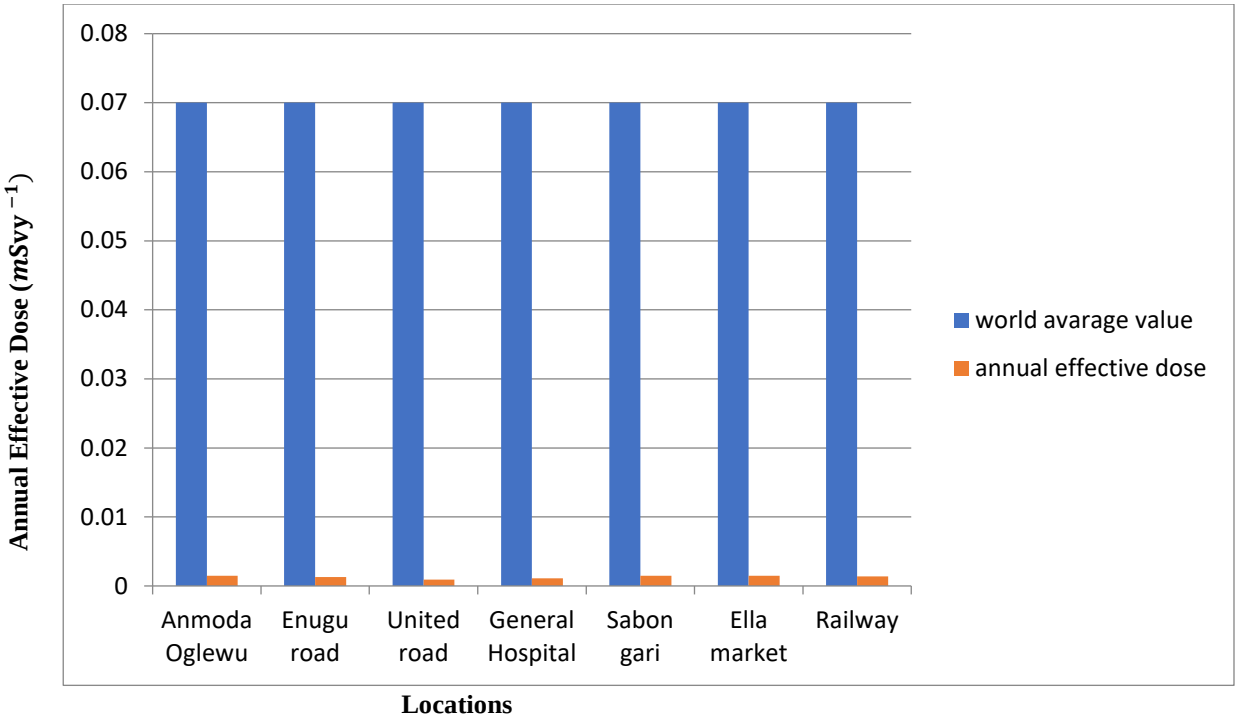

Plate 6: Chart Interpretation of Results of Annual Effective Dose in Otukpo Town Dumpsites

CONCLUSION

The result revealed that Makurdi, Gboko and Otukpo metropolis have annual dose rates lower than the UNSCEAR, (2009) safety limits of 0.07 mSv/y also lower than by (Avwiri and Olatubosun, 2014). The mean annual dose of $0.0013 \pm 0.00 mSvy^{-1}$; $0.0013 \pm 0.00\ mSvy^{-1}$; *and* $0.0013 \pm 0.00\ mSvy^{-1}$ was recorded in Gboko, Makurdi and Otukpo metropolises respectively. This shows that the investigated dumpsites have traces of radionuclides. The presence of potassium-40 (40_K) is lower in all the samples, it is also reported the value of 238_U and 232_{Th} in these dumpsites samples to be much lower than the world wide average value of 35 Bq/Kg and 45 Bq/Kg respectively. Also the value of absorbed dose and annual effective dose rates are reportedly lower than the world average value of 59 nGy/h and 0.07 msv/y.

The following are considered for future studies;

Dust should also be sampled as it is a potential pathway to man, dust carried along with radionuclides through wind.The study is only carried out on selected dumpsites of selected towns but there is need to assess various dumpsites which are exposure to human environ.The study can be expanded to cover grass/vegetation and all other food items, that are potential pathways to man

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