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ASSESSMENT OF BACKGROUND AND SOIL DUMPSITES RADIOACTIVITY IN PLATEAU STATE, NIGERIA

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ABSTRACT: *Assessment of background and dumpsites radioactivity level plays a significant role in the protection of man from excessive radiation exposure. Exposure to high radiation levels causes a wide range of health problems such as cancer of the lung, bone and skin, kidney ailments and blood infections. The background radiation levels of 51 selected dumpsites (3 in each LGA) were obtained at 1m above it using a well-calibrated International Medcom CRM-100 Digital Radiation Monitor. Soil samples were also collected, packed, prepared and analysed with Gamma ray Spectrometer [NaI (Tl) detector]. The mean activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in this study are 61.93±5.90Bq kg^{-1},123.37±34.05 Bq kg^{-1} and 276.54±62.44 Bq kg^{-1} respectively. The mean absorbed dose, AEDE (outdoor) and ELCR in the state have the value of 111 nGyh^{-1}, 0.13 mSv/hr and 0.45 x 10^{-3} respectively, which are greater than the world average value of 58 nGy h^{-1}, 0.07 mSv/hr and 0.29 x 10^{-3} respectively. The mean background radiation of the dumpsites recorded in Plateau State was 204 nGy h^{-1} with the outdoor AEDE of 0.25 mSv/yr and ELCR of 0.88 x 10^{-3} . These values are greater than the world average. The results obtained for the background radiation are higher than those from the radionuclides analysis. The study revealed that the health risks associated with the radionuclide concentrations of soil dumpsites and the background radiation are relatively high, and the use of dumps as manure and other re-cycling processes therefore raises radiological concern.*

KEYWORDS: Background, Radiation, Dumpsite, Exposure, Concentration, Dose.

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INTRODUCTION

Dumps constitute an environmental health hazard to the public in major cities of the world not only in terms of odours or the presence of disease causing microorganisms, but also in terms of possible natural or artificial enhanced radiation from such dumpsites (Martínez-López, Martínez-Sánchez & Pérez-Sirvent, 2021). Environmental pollution is one of the greatest problems the world is facing today and indiscriminate waste dump is one of the major causes of soil contamination (Ukaogo, Ewuzie & Onwuka, 2020). The air and water in areas close to these dumpsites are likely to be contaminated; hence, aerobic respiration becomes difficult for living creatures and safe drinking water becomes scarce. Contamination is the misuse of land in a way which makes it unfit for man's future needs, such as growth of food crops or construction of buildings. The disposal of these mining dumps without adequate management can lead to exposure of the populace to radiation (Ukaogo, Ewuzie & Onwuka, 2020).

LITERATURE/THEORETICAL UNDERPINNING

Waste is a part of human life and some wastes contain radioactive elements which naturally and continually emit particles such as α-particles, β-particles and gamma rays. These radioactive elements can stay for ten million years and above. Little wonder the half-life of some of these elements is about a million years and above. These radioactive elements might be present in the mining dumps that were disposed of recently or a long time ago. Natural background radiation levels are likely to vary with human activities and natural processes; it may also change with locations due to different mineralogical, deformational and climatic factors responsible for the syngenetic processes for mineral formation (Ahmed, N. S., Ahmed, O., Sayed & Tawfic, 2020).

In Plateau State, waste collection is on a daily basis and some have been accumulated for years and have had very considerable impacts on the environment. Exposure to high radiation levels causes a wide range of health problems such as cancer of the lung, bone and skin, kidney ailments and blood infections (UNSCEAR, 2010). Assessment of background radioactivity level plays a significant role in the protection of man from excessive radiation exposure (Abodunrin, Ademo & Akinbo, 2017). Data on radioactivity concentrations and the exposures from the dumpsites are scanty in comparison to the dumps we have around us. Consequently, there is a general lack of awareness and knowledge of the radiological hazards and exposure levels by legislators, regulators and operators. This is particularly significant as people use the contaminated soils as organic manure for farming and food production. The inhabitants of the area are often without any knowledge about the perils of the contaminated soils, water, as well as air which is a serious long-term human catastrophe. Ionizing radiation has often been overlooked amongst researchers in third world countries and so information in this regard is scarce (Verla, A.W.; Enyoh, Okonkwo; & Verla, E.N., 2017), hence the need for this research. Activities involving naturally occurring radioactive materials are potential sources of radiation exposure to workers and members of the public in general (Verla et al., 2017). Exposure to ionizing radiation is generally undesirable at all levels to the public. The waste dumps have been mostly used as manure in the farm with little attention being paid to the dangers that the famers and the other end consumers could be exposed to in terms of radiation exposure (Daburum, 2023). There is therefore a growing need to investigate the

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health risks associated with such exposure due to natural sources of radiation in these areas. The results obtained in this research will serve as baseline data and sources of reference for future radiological impact evaluation studies, providing a database which may be incorporated into the Nigeria Nuclear Regulatory Agency (NNRA) resources for National Planning.

METHODOLOGY

The following materials were used in data collection and analysis: Thirty-five (35) one kilogram capacity plastic bottles, labeling stickers, hot air oven, shovel, packing tape, mesh sieves of different diameters, 76 mm × 76 mm, Thallium Gamma Spectrometer with sodium iodide [NaI (Tl)] detector, PCA-P software, Oxford Win-MCA, and lastly certified reference samples as per (IAEA, 1987).

Plateau State is located near the central part of Nigeria; it covers 8600km^2 from latitudes 9^{o}36 to 9^{o}60^{l}N and longitudes 8^{o}32 to 8^{o}56^{l}E, and is bounded by 300-600 meter escarpments around most of its circumference, with an average altitude of 1280 metres and its highest point at 2010 metres. It is the only region of temperate climate in Nigeria. It is within the Nigerian basement complex and the younger granite complex, covering Jos-Bukuru complex, Ganawuri, Rukuba, Kagoro, Miango, Forum and Kigom complex. The rock types of the basement complex comprise a group of older granulite gneisses succeeded by a series of migmatite, granite-gneisses and granites, forming a single petrogenetic unit. Major towns include Jos, Bukuru, Rukuba, Barkin Ladi, Ganawuri, Vom, and Kigom, which fall within Plateau State. The residents of the area are mainly farmers, miners and civil servants (Plateau State Government, 1991 cited by Lucky & Temitayo, 2017).

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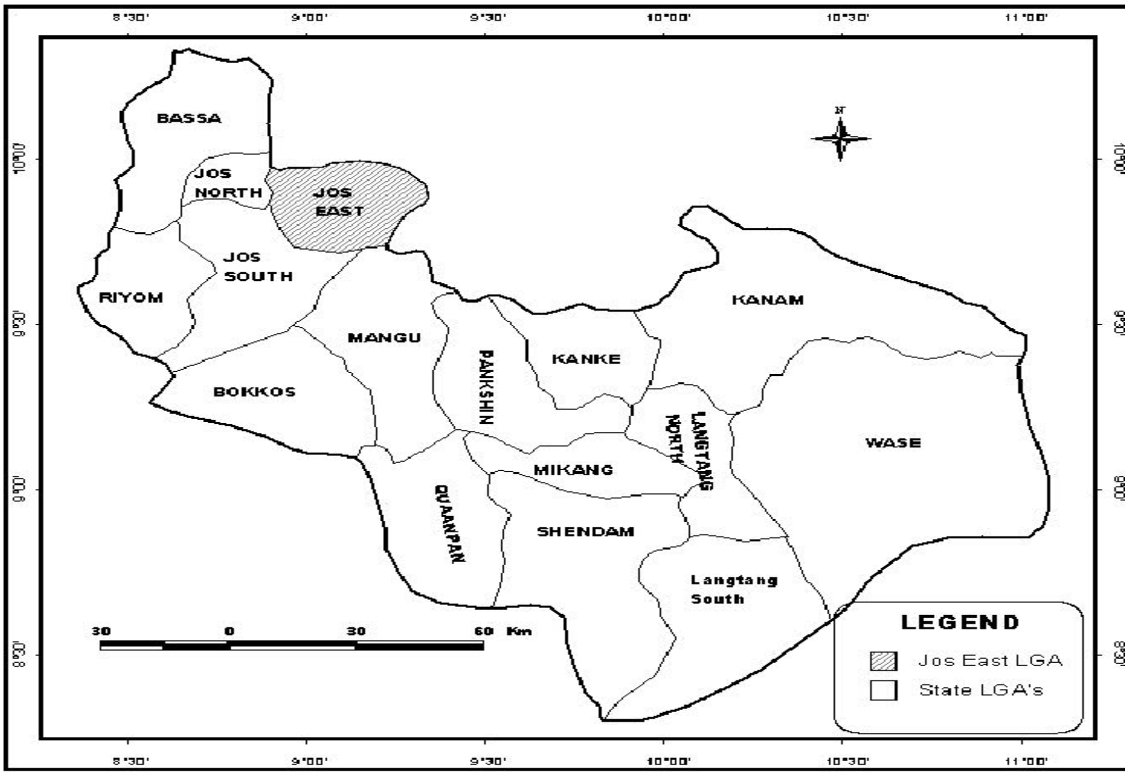

Fig. 1: Map of Plateau State showing the LGAs

A cross-sectional survey design was adopted for the study and was conducted at all the major dumpsites within 17 LGAs of Plateau State, Nigeria. These dumpsites were selected using a single-stage cluster sampling technique. The background radiation levels at the selected dumpsites were obtained using a well-calibrated International Medcom CRM-100 Digital Radiation Monitor. The CRM-100 is a general-purpose Geiger counter that measures alpha, beta, gamma, and X-radiation. It has a liquid crystal display (LCD) screen that shows the current radiation level in users' choice, milli-roentgens per hour (mR/hr), counts per minute (CPM), micro-sieverts per hour (µSv/hr), and counts per second (CPS). An in situ (in the normal location) background radiation measurement approach was adopted following standard procedure described by Masok, Masiteng and Jwanbot (2015) in which the radiation monitor was held at a distance of 1.0 meters above the ground and the mean of (at least) three readings taken at each location was recorded. This radiation meter has a maximum response to environmental radiation during the hours of 1300 to 1600 (13); hence, the readings were taken during this period for optimum results. The values of readings obtained for each dumpsite were presented in a table. For measuring mixed alpha, beta, and gamma radiation, the counts per minute (CPM) mode was used.

Soil samples were collected from two out of the three dumpsites in each of the 17 LGAs of Plateau State, Nigeria. Thirty-four (34) samples were collected in different sites in the state. These samples were collected using a hand trowel digging at a depth 0.15m to obtain representative samples of the radionuclides. The soil was properly mixed, packed in the black labelled polythene bag provided, sealed and taken to the laboratory (MP Physics Laboratory, Federal College of Education, Pankshin Plateau State, Nigeria) for preparation. In the

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laboratory, the samples were air dried to remove moisture, pulverized into fine powder for greater surface area using a mini mortar and pestle before being homogenized by sieving with a 2 mm sieve (Jibiri & Okeyode 2012). Dried samples weighing 0.5kg were measured, packed into a white cylindrical plastic PVC container, labelled appropriately, sealed and airtight with a paper tape and transported to Centre of Energy and Research (CERT), Ahmadu Bello University, Zaria for analysis. The analysis was done with Gamma Spectrometer with a sodium iodide [NaI (Tl)] detector, PCA-P software, Oxford Win-MCA and lastly certified reference samples as per (IAEA, 1987).

The containers were sealed and airtight to prevent escape of gaseous ^{220}Rn and ^{222}Rn, and incubated for about a month to bring the daughter radionuclide into secular radioactive equilibrium.

The background radiation readings obtained in $\frac{\mu rem}{hr}$ were converted to exposure in µSv/hr using Equation 1:

$$1\,\frac{\mu rem}{hr} = 0.01\ \mu\text{Sv/hr} \qquad (1)$$

To convert the exposure rate in µSv/hr to absorbed dose in nGy/hr using Equation 2:

$$\frac{1\mu Sv}{hr} = 10^{-3} nGy/hr \qquad (2)$$

The Annual Effective Dose Equivalent (AEDE) is calculated by applying the conversion factors of 0.70 $SvGy^{-1}$, which converts absorbed dose rate in the air to effective dose and the outdoor occupancy factor of 0.2, assuming that an individual spends an average of 80% of his time indoors. The standard AEDE (outdoor) value is $70\mu Svyr^{-1}$ and that for AEDE (indoor) is $450\mu Svyr^{-1}$. These indices measure the risk of stochastic and deterministic effects in the irradiated individuals (Rajaraman, Hauptmann, Bouffler & Wojcik, 2018). This is evaluated using Equation 3:

$$AEDE = D(nGyh^{-1}) \times 8760(hy^{-1}) \times 0.7(\frac{Sv}{Gy}) \times 0.2 \times 10^{-6} \qquad (3)$$

Excess Lifetime Cancer Risk (ELCR), according to Mas et al. (2021), is associated with the probability of developing cancer over a lifetime at a given exposure level. It is a value depicting the number of cancers expected in a given number of people on exposure to a carcinogen at a given dose (Kolo, Amin Khandaker & Abdullah, 2017). This is computed with Equation 4:

$$ELCR = AEDE \times DL \times RF \qquad (4)$$

where AEDE is the Annual Effective Dose Equivalent, DL is the average duration of life (70 years) and RF is the Risk Factor (0.05 Sv^{-1}). The obtained data were analyzed using statistical package for social sciences (SPSS version 20, SPSS Inc, Chicago IL, USA). Descriptive statistics (mean, standard deviation) of various background radiation values was obtained.

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RESULTS /FINDINGS

Activity Concentrations of ^{226}Ra, ^{232}Th And ^{40}K in the Dumpsite Soil

Activity concentrations of primordial radionuclides in sand samples collected at the dumpsites across Plateau state were determined and presented in Table 1.

Table 1: Radionuclide Concentrations of soil Dumpsite with Associated Exposures and Risks

		Activity Concentration in ($\boldsymbol{BqKg^{-1}}$)			Exposures/ Ratio		
S/N	Sample ID	^{226}Ra	^{232}Th	^{40}K	$D_R(nGyh^{-1})$	$AEDE$ $(mSvy^{-1})$ Outdoor	ELCR x 10^{-3}
1	Barkin Ladi	46.71±4.83	80.92±3.22	340.91±7.88	89.18	0.11	0.38
		36.68±6.67	144.14 ±2.95	162.71±7.99	115.99	0.14	0.49
2	Riyom	26.25±2.76	28.98±1.18	267.34±3.16	42.90	0.05	0.18
		338.99 ±7.43	227.97 ±9.79	155.41 ±11.21	310.61	0.38	1.32
3	Jos South	129.78 ±4.56	191.68 ±3.74	275.97±7.72	191.92	0.23	0.81
		82.67±4.67	106.32 ±6.57	731.65±8.90	139.42	0.17	0.59
4	Bassa	161.07 ±6.47	191.33 ±3.85	121.90±7.56	200.69	0.24	0.85
		59.54±2.84	131.72 ±1.85	469.67±8.10	129.41	0.16	0.55
5	Jos North	30.09±0.92	43.80±1.10	243.36±4.67	51.79	0.06	0.22
		26.29±5.51	181.14 ±4.88	47.19±7.35	129.32	0.16	0.55
6	Jos East	37.36±4.75	114.97 ±3.22	518.47±7.99	112.80	0.14	0.48
		42.07±7,43	82.85±2.63	497.83±7.40	95.57	0.12	0.41
7	Mangu	19.70±3.32	86.07±1.65	208.67±4.29	72.50	0.09	0.31
		43.39±5.07	178.70 ±2.63	135.52±8.47	137.93	0.17	0.18
8	Pankshin	24.81±5.51	140.29 ±2.28	210.97±6.97	109.21	0.13	0.58
		47.71±3.16	81.63±2.04	480.51±7.35	94.38	0.11	0.46
9	Bokkos	36.00±2.56	62.36±1.26	429.94±7.88	74.50	0.09	0.40
		15.82±4.00	47.65±2.24	179.76±7.51	47.10	0.06	0.32
10	Kanke	51.58±6.83	106.59 ±3.50	265.51±8.10	104.89	0.13	0.20
		47.87±6.67	121.93 ±9.12	141.63±8.37	110.61	0.13	0.44

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11	Kanam	8.99±4.56	132.27 ±2.79	289.91±8.31	100.27	0.12	0.47
		23.49±2.44	118.00 ±3.46	181.80±6.60	93.20	0.11	0.43
12	Wase	50.55±6.31	148.90 ±3.18	190.65±6.44	126.35	0.15	0.40
		11.75±4.67	120.24 ±8.81	541.43±8.26	108.45	0.13	0.54
13	Langtang North	126.46 ±5.35	206.46 ±5.43	505.98±9.90	210.40	0.25	0.46
		98.03±1.62	74.43± 2.28	178.58 ±1.29	97.72	0.12	0.42
14	Langtang south	89.45±1.42	72.07±1.69	153.97±0.69	91.31	0.11	0.39
		92.48±1.32	72.82±1.26	124.42±0.05	91.93	0.11	0.39
15	Mikang	89.33±1.20	78.95±0.98	115.35±0.11	93.80	0.11	0.39
		70. 43±2.23	62.52±1.57	163.78±0.80	77.16	0.10	0.35
16	Shendam	85.37±1.20	66.49±1.34	156.92±0.75	86.17	0.10	0.35
		79.10±1.78	58.03±1.22	148.60±1.45	77.81	0.10	0.35
17	Quanpan	81.50±0.84	57.72±1.10	134.28±1.34	78.14	0.10	0.35
		75.82±0.32	62.05±1.02	179.39±1.82	80.01	0.10	0.35
	Minimum	8.99±4.56	47.65±2.24	135.52±8.47	1.61	0.10	0.15
	Maximum	126.46 ±5.35	206.46 ±5.43	541.43±8.26	9.97	1.46	3.41
	Mean Value						
World Average (UNCEAR, 2000)		30.00	35.00	400.00	1.41	0.08	0.11

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Table 2: Radiation Dose Exposures and Risks from Soil Dumpsites across the 17 LGAs

S/N	LGA	Absorbed dose (nGy/hr)	AEDE outdoor (mSvyr)	ELCR x 10^{-3}
1	Barkin Ladi	103	0.13	0.44
2	Riyom	177	0.22	0.75
3	Jos South	166	0.20	0.70
4	Bassa	165	0.20	0.70
5	Jos North	91	0.11	0.39
6	Jos East	104	0.13	0.45
7	Mangu	105	0.13	0.25
8	Pankshin	102	0.12	0.52
9	Bokkos	61	0.08	0.36
10	Kanke	108	0.13	0.32
11	Kanam	97	0.12	0.45
12	Wase	117	0.14	0.47
13	Langtang North	154	0.19	0.44
14	Langtang south	92	0.11	0.39
15	Mikang	85	0.11	0.37
16	Shendam	82	0.10	0.35
17	Quanpan	79	0.10	0.35
	Minimum	61	0.08	0.25
	Maximum	177	0.22	0.75
	Mean	111	0.13	0.45

Radiation exposure rates were obtained from 51 locations of dumps, three in each of the 17 LGAs (Table 3). The mean exposure for the dumpsite in each LGA was computed and presented in Table 4. Calculated values of absorbed dose rate (D_R), annual absorbed dose rate (AEDE) and effective life cancer risk (ELCR) are presented in Table 4.

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Table 3: Background Radiation at 1m above the Dumpsites

S/N	LGA	Location	Gamma Activity Level/ µRem/hr	Exposure Rates/ µSv/hr	Absorbed dose (nGy/hr)	AEDE outdoor (mSvyr)	ELCR x 10^{-3}
1	Barkin Ladi	Heipang	15	0.15	150	0.184	0.644
		Fan	22	0.22	220	0.270	0.944
		Kassa	18	0.18	180	0.221	0.773
2	Riyom	Ta-hoss	26	0.26	260	0.319	1.116
		Ra-hoss	21	0.21	210	0.258	0.901
		Kwi	22	0.22	220	0.270	0.944
3	Jos South	Du	24	0.24	240	0.294	1.030
		Anguldi	29	0.29	290	0.356	1.245
		Dadin Kowa	25	0.25	250	0.307	1.073
4	Bassa	Bassa	25	0.25	250	0.307	1.073
		Jebbu-Bassa	26	0.26	260	0.319	1.116
		Jebu ketago	27	0.27	270	0.331	1.159
5	Jos North	Terminus	22	0.22	220	0.270	0.944
		Faringada	24	0.24	240	0.294	1.030
		Kabong	24	0.24	240	0.294	1.030
6	Jos East	Doss	19	0.19	190	0.233	0.816
		Foburii. Fobur	16	0.16	160	0.196	0.687
		Fogom	15	0.15	150	0.184	0.644
7	Mangu	Tsohor Kasuwa	19	0.19	190	0.233	0.816
		Panyam	19	0.19	190	0.233	0.816
		Gindiri	22	0.22	220	0.270	0.944
8	Pankshin	Main Market	17	0.17	170	0.208	0.730
		Daily Market	19	0.19	190	0.233	0.816
		F. C. E. Bank	21	0.21	210	0.258	0.901
9	Bokkos	Mabel	20	0.2	200	0.245	0.858
		Cottage Taddung	22	0.22	220	0.270	0.944
		Luna Hospital	20	0.2	200	0.245	0.858
10	Kanke	Kabwir	18	0.18	180	0.221	0.773
		Amper	17	0.17	170	0.208	0.730
		Dawaki	18	0.18	180	0.221	0.773
11	Kanam	Bankilong	22	0.22	220	0.270	0.944
		Dengi	24	0.24	240	0.294	1.030
		Gidgid	18	0.18	180	0.221	0.773
12	Wase	Kadarko	19	0.19	190	0.233	0.816
		Wadata	19	0.19	190	0.233	0.816
		Kumbur	18	0.18	180	0.221	0.773

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13	Langtang North	Shishiri	19	0.19	190	0.233	0.816
		Prison	18	0.18	180	0.221	0.773
		Gazum	20	0.2	200	0.245	0.858
14	Langtang south	Mabudi	20	0.2	200	0.245	0.858
		Sabongida	19	0.19	190	0.233	0.816
		Takalafiya	18	0.18	180	0.221	0.773
15	Mikang	Lifidi	19	0.19	190	0.233	0.816
		Paipung	20	0.2	200	0.245	0.858
		Koeneom	18	0.18	180	0.221	0.773
16	Shendam	Naburuk	18	0.18	180	0.221	0.773
		Shrimankar	19	0.19	190	0.233	0.816
		Zomo	20	0.2	200	0.245	0.858
17	Quanpan	Namu	18	0.18	180	0.221	0.773
		Gidan adamu	20	0.2	200	0.245	0.858
		Kurgwi	18	0.18	180	0.221	0.773
	Min		15	0.15	150	0.184	0.644
	Max		29	0.29	290	0.356	1.245
	Mean		20	0.20	204	0.250	0.875

Table 4: Mean Background Radiation at 1m above the Dumpsites of the 17 LGAs

S/N	**LGA**	**Absorbed dose (nGy/hr)**	**AEDE outdoor (mSvyr)**	**ELCR x 10^{-3}**
1	Barkin Ladi	183	0.22	0.79
2	Riyom	230	0.28	0.99
3	Jos South	260	0.32	1.12
4	Bassa	260	0.32	1.12
5	Jos North	233	0.29	1.00
6	Jos East	167	0.20	0.72
7	Mangu	200	0.25	0.86
8	Pankshin	190	0.23	0.82
9	Bokkos	207	0.25	0.89
10	Kanke	177	0.22	0.76
11	Kanam	213	0.26	0.92
12	Wase	187	0.23	0.80
13	Langtang North	190	0.23	0.82
14	Langtang south	190	0.23	0.82
15	Mikang	190	0.23	0.82
16	Shendam	190	0.23	0.82
17	Quanpan	187	0.23	0.80
	Min	167	0.20	0.72
	Max	260	0.32	1.12
	Mean	204	0.25	0.88

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DISCUSSION

The activity concentrations of ^{226}Ra in this study ranged from 8.99±4.56 to 126±5.35 Bq kg $^{-1}$ with a mean 61.93±5.90 Bq kg^{-1}, while the activity concentrations of ^{232}Th and ^{40}K varied from 47.65±2.24 to 135.52±8.47 and 206.46±5.43 to 541.43±8.26Bq kg^{-1}, with mean values of 123.37±34.05 and 276.54±62.44 Bq kg^{-1} respectively. The error quoted is the standard deviation showing the spatial variation within the samples. Jos Plateau is known to be a High Background Radiation Area (Farai & Jibiri, 2000). Due to the local geology of the area, high levels of thorium, most especially in monacites soils (Okeyode & Ganiyu, 2009), and uranium and its decay products in the rocks are sources that enhance high background radiation which reflects in the result obtained in Table 1, with obtained average exceeding the world population weighted average of 35, 30 and 400 Bq kg^{-1} for ^{226}Ra, ^{232}Th and ^{40}K respectively (Beretka & Mathew, 1985; UNSCEAR, 2000; Okeyode & Akanni, 2009; Manigandan & Shekar, 2014; Ravinsankar et al., 2014). Potassium ^{40}K has the highest activity concentrations because it is relatively abundant in the earth crust (Okedeyi et al., 2012), due to the presence of potassium bearing minerals such as feldspar microcline, and biotite in the soil (Huang, 2005; Okeyode & Ganiyu, 2009).

The absorbed dose, AEDE (outdoor) and ELCR calculated across the 17 LGA in this investigation and was found to range from 61-177 nGy h^{-1}, 0.08 -0.22 mSv/hr and 0.25-0.75 x 10^{-3} respectively. The mean absorbed dose, AEDE (outdoor) and ELCR in the state have values of 111 nGyh^{-1}, 0.13 mSv/hr and 0.45 x 10^{-3} respectively, which are greater than the world average value of 58 nGy h^{-1}, 0.07 mSv/hr and 0.29 x 10^{-3} respectively (UNSCEAR, 2010).

The mean background radiation of the dumpsites recorded in Plateau State was 204 nGy h^{-1} with the outdoor AEDE of 0.25 mSv/yr and ELCR of 0.88 x 10^{-3}. These values are greater than the world average.

The two different results of the absorbed dose rate (D_R), annual absorbed dose rate (AEDE) and effective life cancer risk (ELCR) of the dumpsites across the 17 LGAs were compared as presented in Figures 1, 2 and 3. It can be seen from those figures that the background radiation exposures are greater than the radionuclide exposures which could be attributed to other sources around the dumpsites.

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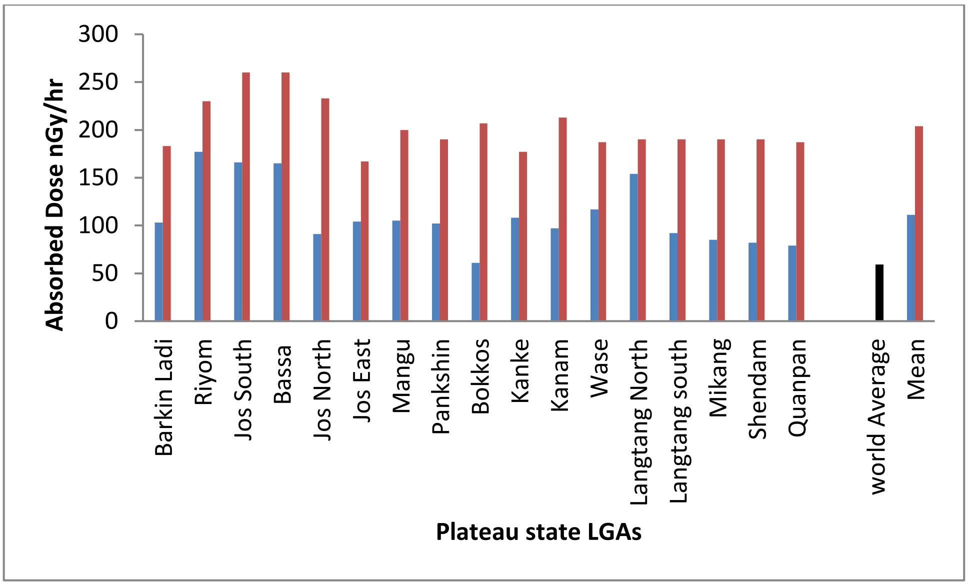

Figure 1: Comparison of Radionuclide and Background Absorbed Doses of Dumpsites

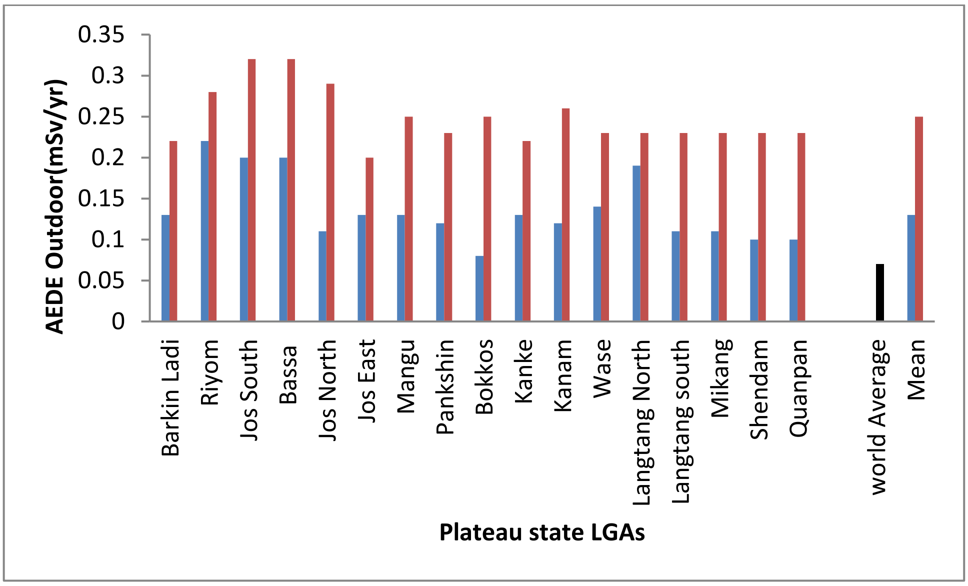

Figure 2: Comparison of Radionuclide and Background AEDE of Dumpsites

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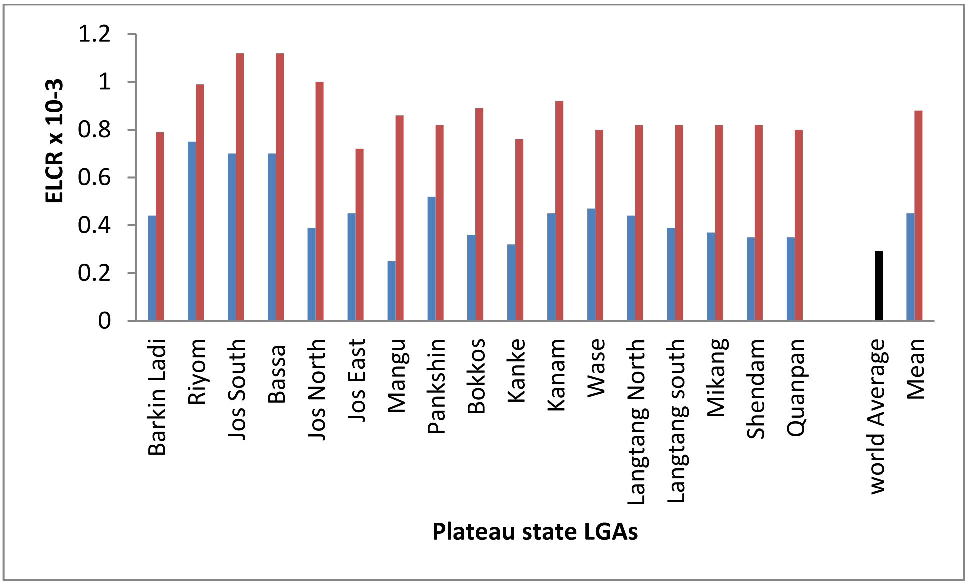

Figure 3: Comparisons of Radionuclide and Background ELCR of Dumpsites

IMPLICATION TO RESEARCH AND PRACTICE

Exposure to high radiation levels can cause a wide range of health problems such as cancer of the lung, bone and skin, kidney ailments and blood infections. The study revealed that the health risks associated with the radionuclide concentrations of soil dumpsites and the background radiation are relatively high, hence the use of dumps as manure which is a common practice in the state, and other re-cycling processes, therefore raising radiological concern.

CONCLUSION

The natural radionuclide and background radiation of selected dumpsites in Plateau State, Nigeria were determined. The specific activity concentrations of ^{226}Ra in this study ranged from 8.99±4.56 to 126±5.35 Bq kg $^{-1}$ with a mean of 61.93±5.90Bq kg^{-1}, while the activity concentrations of ^{232}Th and ^{40}K varied from 47.65±2.24 to 135.52±8.47 and 206.46±5.43 to 541.43±8.26Bq kg^{-1}, with mean values of 123.37±34.05 and 276.54±62.44 Bq kg^{-1} respectively. The average values are greater than the world population weighted average of 35, 30 and 400 Bq kg^{-1} for ^{226}Ra, ^{232}Th and ^{40}K respectively. The absorbed dose, AEDE (outdoor) and ELCR calculated across the 17 LGAs in this investigation were found to be 61-177 nGy h^{-1}, 0.08 -0.22 mSv/hr and 0.25-0.75 x 10^{-3} respectively. The mean absorbed dose, AEDE (outdoor) and ELCR in the state have values of 111 nGyh^{-1}, 0.13 mSv/hr and 0.45 x 10^{-3} respectively, which are greater than the world average value of 58 nGy h^{-1}, 0.07 mSv/hr and 0.29 x 10^{-3} respectively. The mean background radiation of the dumpsites recorded in Plateau State was 204 nGy h^{-1} with the outdoor AEDE of 0.25 mSv/yr and ELCR of 0.88 x 10^{-3}. These values are greater than the world average and the computed values from radionuclides of the sampled soil dumps.

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FUTURE RESEARCH

The following are recommended for further research:

1. Heavy metals analysis of the dumpsites can be further analyzed.
2. The exposure of the crops as results of the used dumps as manure needs to be investigated.

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