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NORMs DISTRIBUTION IN COASTAL SOILS AND SEDIMENTS OF RIVER YOBE, NORTH-EASTERN NIGERIA: AN EVALUATION OF THE POTENTIAL RADIOLOGICAL HAZARDS

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ABSTRACT
A preliminary study which aimed to establish a reference data on naturally occurring radioactive materials (NORMs) for River Yobe has been conducted. Soil and sediment samples were collected along the coastal areas of the river and analyzed to determine the specific activities of NORMs such as ^{238}U, ^{232}Th and ^{40}K. Gamma spectrometry technique using NaI (Tl) detector was employed to determine the specific activities of the natural radionuclides. The mean activity concentration in the soil samples for ^{238}U, ^{232}Th and ^{40}K were found to be 23 ± 1.5, 36 ± 2.5 and $395\pm9.1 Bq\ kg^{-1}$ and for the sediment samples are 60 ± 2.6, 45 ± 3.6 and $324\pm6.8 Bq\ kg^{-1}$ respectively. These values, in some cases exceed the world reference values of 30, 35 and 400 Bq kg^{-1} for ^{238}U, ^{232}Th and ^{40}K respectively. Parameters of radiological hazard, were also estimated based on specific activity of the radionuclides to assess the radiological impacts due to exposure on the users of the river. The results were found to be within the worldwide recommended safety limits.
Keywords: Annual effective dose, NORMs, ^{238}U.^{232}Th.^{40}K. River Yobe

INTRODUCTION

Every living creature is continuously exposed to ionizing radiation that stem from either primordial activities or fission activities that are controlled by man(Ithier-Guzman & Pyrtle, 2005). The primordial radiation has been part and parcel of the earth while cosmogenic radiation comes from cosmos and find their ways into human food chain and biota (Kurnaz *et al.*, 2007). Natural and artificial radiations from ground, building materials, water, air, food, the universe, particles in their bodies, atomic bomb test, and nuclear reactor accidents are the main contributors to human exposure(Kurnaz et al., 2007).

There're active uranium mines in Niger Republic, which is one of the major catchment areas of River Yobe. Tailing piles at the Cominak And Somaïr mines have been shown to result in discernable environmental ramifications (Déjeant *et al.*, 2014). By measuring specific activities of NORMs in suspended materials in Iberian rivers that had their source from uranium mining and milling region, Carvalho, Oliveira, and Malta (2014a) detected significant levels of leached activities in River Mondego and River Zezere, which have their tributaries receiving drainage from uranium miningdistricts in Portugal. The work of Carvalho et al. is relevant to the current study and has lead the current authors to hypothesize that NORMs concentrations would be elevated in the sediments of River Yobe.

Particulate materials (e.g radioactive materials) and dissolved species from the land are transported to the sea by the rivers (Chowdhury, Alam, & Hazari, 1999). Radioactive materials that are transported by rivers and the sea find their ways into human food chain through aquatic animals consumption (e.g. Chen, 2013) and crops from irrigation farming (e.g. Carvalho et al., 2014a; Carvalho, Oliveira, & Malta, 2014b).Sediments from the rivers mostly consists of silicate and minerals with high cation exchange capacity. The radionuclides in the sediments are retained by the clay particles and as the sediments are used along with other building materials, they act as a medium of migration to transfer these radionuclides to the biological system (Hariprasath, Jose, Vijayalakshmi, & Rajesh, 2016). In addition, the sediment sand fromRiverYobe is intensively used for construction of houses and other important civil structures in the area.

An investigation of specific concentrations of NORMs in rivers and coastal ecosystems is required in curtailing the effects of future accidents which might involve the spillage of radioactive materials in the biota. Currently there is no data concerning the distributions of NORMs in the sediment and soil of River Yobe and its coastal areas. In the current work, soils and sediments were collected from the river and its coastal area, and laboratory analyses were conducted using gamma spectroscopy to measure the activity concentrations of natural radionuclides (^{232}Th, ^{238}U, Ra and ^{40}K).

MATERIALS AND METHODS

The Study Area

The Yobe River (*Komadougou Yobe*) is situated between latitudes 10° N and 13° N and longitudes 9.45° E and 12.30° E of prime meridian, in the north-eastern region of Nigeria. It is one of the major rivers that drain into Lake Chad from Niger Republic through Nigeria. Its tributaries include the Jama'are River, the Hadeja River and the Komadugu Gana River. The riverforms the border between the two countries for some distance of 150 km and flow a total distance of 320 km to empty into the western end of Lake Chad (El-Ishaq, Omotayo, & Hussaini, 2016). Notable towns near the river include Gashua, Geidam, and Damasak in Nigeria, and Diffa in Niger(El-Ishaq *et al.,* 2016). The river is being used by the thousands of resident living on its both sides as a source of water for drinking, irrigation work and fishing activities throughout the year(M Waziri & Ogugbuaja, 2010). In addition, the river is also used for disposal of domestic, agricultural wastes and municipal sewage (El-Ishaq *et al.*, 2016). Therefore, agrochemicals such as fertilizers, pesticides, herbicides and dumping of refuse by the riverside are the main contaminants of the river (M. Waziri, 2010). Map showing River Yobe is given in Figure 1.

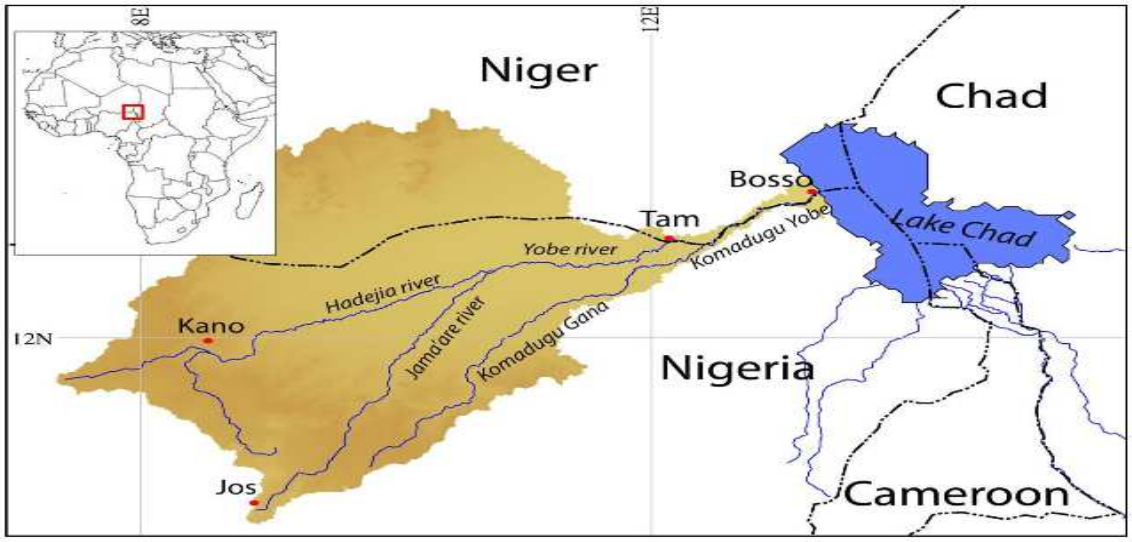

Figure1: Map showing the River Yobe

Sample Collection and Preparation

Sediment samples were taken at about 5 to 10 m away from the river side and at about 1-2 m water depth. An interval of 1 km was considered between the sampling points. In all, 30 sampling points (for both soils and sediments) were collected for analysis. Soil samples along the river banks were collected at 3–20 m distance away from the river banks(Chowdhury *et al.*, 1999).

Pebbles, grasses and pieces of woods were removed from the samples before packaging them in a labeled plastic bags. Each of the samples collected, weighted about 1–1.5 kg. The samples were dried in an open air at ambient temperature for 15 days and later pulverized using agate mortar before they were sieved and homogenized through a 0.2 cm mesh. The homogenized samples were then weighed and transferred to plastic cylinders (60 mm in height, 65mm in diameter), sealed and kept for 30 days to attain secular equilibrium between radium and its daughter nuclide(Mollah, Rahman, Koddus, Husain, & Malek, 1987; Omar, Ibrahim, Hassan, Lau, & Ahmad, 1993; Saleh, Ramli, Alajerami, Aliyu, & Basri, 2013a). Samples preparation and all radioactivity counting were conducted at the Center for Energy Research and Training (CERT), Ahmadu Bello University, Zaria, Nigeria.

Gamma Spectrometry Analysis

The γ-ray activities in both soil and sediment samples were measured using a gamma spectrometry system consisting of a 76 mm 76 mm NaI (Tl) detector joined to a Multichannel Analyzer (MCA) through a base of preamplifier. The detector has 8% at gamma energy of 0.662 MeV resolution, which is enough to distinguish the gamma ray energies of the radionuclides of interest. The energy peaks at 1.461 MeV, 1.764 MeV from ^{214}Bi and 2.615 MeV from ^{208}Tl were used to determine the specific activity of ^{40}K ^{238}U and ^{232}Th, respectively (IAEA, 1989; ICPC., 1983; Siemon et al., 1992). All samples were counted for the time of 36000s (10h). The background counts in the environment around the detector's room were striped. The net area for each energy peak, was used to compute the specific activity concentration of each radionuclide within the samples. The specific activity concentration was computed using equation1(Ademola & Farai, 2006; Isinkaye, 2013).

$$C(Bqkg^{-1}) = \frac{C_n}{\varepsilon p_\gamma M_s} \qquad (1)$$

Where C is the specific activity concentration of the radionuclide in the sample, C_n is the count rate for the corresponding energy peak,$\varepsilon$is the efficiency of the detector at the specific gamma ray energy, $P_\gamma$is the absolute transition probability of the specific γ-ray and *Ms* is the mass of the sample in Kg.

The minimum detection limit (MDL) in Bq kg^{-1} was estimated using equation 2. This is defined as the capability of the measuring system to detect without sample (Jibiri, Farai, & Alausa, 2007).

$$MDL = 1.96\frac{[B/T + SD_b^2]^{1/2}}{k \times \varepsilon \times m}, \qquad (2)$$

S.D is the standard error for the net background count, with corresponding counting time T, K is a conversion factor from dpm to Bq and 1.96 represent 95 level of confidence (Aliyu, Ibrahim, Akpa, Garba, & Ramli, 2015). The MDL were estimated to be 3.5 Bq kg^{-1} for both ^{232}Th and ^{238}U and 67 Bq kg^{-1} for ^{40}K for the counting time of 10 h.

RESULTS AND DISCUSSION

Specific Activity Concentrations of ^{238}U, ^{232}Th series and ^{40}K

Specific activity concentrations for the gamma emitting radionuclides of the ^{238}U, ^{232}Th and ^{40}K in the soil and sediment samples are presented in Table 1 and 2. In soil samples, the activity concentrations of ^{238}U, ^{232}Th, and ^{40}K ranged from 10±0.3 to 83±4.3 Bq kg^{-1}, 22±1.7 to 62±4.1 Bq kg^{-1} and 92±6.2 to 688±12.7Bq kg^{-1} with average value of 23±1.5 Bq kg^{-1}, 36±2.5 Bqkg^{-1} and 395±9.1Bq kg^{-1} (dry weight), respectively. While in sediment samples, the concentrations ranged from 15±0.5 to 188±5.5Bq kg^{-1}, 20±1.2 to 73±6.1Bq kg^{-1} and 170±4.8 to 525±12.4Bq kg^{-1} with average values of 60±2.6Bq kg^{-1}, 45±3.6Bqkg^{-1} and 324±6.8Bq kg^{-1} (dry weight), respectively. The worldwide mean reference values for concentrations of ^{238}U, ^{232}Th, and ^{40}K in soil samples is 30, 35, and 400 Bqkg^{-1}, respectively (UNSCEAR, 2000). It was noted that the measured activities of the three radionuclides in soils and sediments differed widely. This is due to the fact that the activity levels in the freshwater environment primarily depend on their geo-chemical, physical properties and the environment as observed by(Alfonso *et al.*, 2014).Variation among the radioactivity concentration for different locations may also due to geological condition and drainage pattern of the study area location (Ravisankar *et al.*, 2015).

Table 1: Activity concentrations, Radium equivalent (Ra_{eq}) and external absorbed dose rates in soil samples

Sample ID.	^{226}U (Bqkg^{-1})	^{232}Th (Bqkg^{-1})	^{40}K (Bqkg^{-1})	Ra_{eq} (Bqkg^{-1})	Dose rate (nGyh^{-1})
S1	10±0.3	36±2.3	480±11.2	99	47
S2	22±1.2	38±2.4	465±10.9	112	53
S3	18±0.8	41±3.0	425±10.5	110	51
S4	13±0.3	35±2.1	441±9.8	98	46
S5	22±1.3	32±2.0	117±4.4	77	35
S6	20±1.1	28±1.9	532±11.8	102	49
S7	20±1.2	33±2.1	643±12.5	116	56
S8	27±1.8	49±3.8	688±12.7	151	72
S9	15±0.7	43±3.2	475±11.1	114	54
S10	16±0.6	33±2.3	316±8.8	87	41
S11	15±0.5	23±1.8	270±6.4	69	32
S12	17±0.9	40±3.0	538±10.9	116	55
S13	16±0.7	32±2.1	337±8.9	88	41
S14	83±4.3	22±1.7	092±5.8	122	56
S15	28±2.2	62±4.1	105±6.2	126	56
Min.	10±0.3	22±1.7	92±5.8	69	32
Max.	83±4.3	62±4.1	688±12.7	151	72
Mean	23±1.5	36±2.5	395±9.1	106	50

Table 2: Activity concentrations, Radium equivalent activities (Ra_{eq}) and absorbed dose rates in sediment samples

Sample ID.	^{238}U (Bqkg^{-1})	^{232}Th (Bqkg^{-1})	^{40}K (Bqkg^{-1})	Ra_{eq} (Bqkg^{-1})	Dose rate (nGyh^{-1})
S1	25±1.0	44±3.4	170 ±4.8	100	45
S2	47±3.2	43±3.4	226±6.0	127	58
S3	22±0.9	50±4.1	196±5.2	110	50
S4	25±1.1	59±4.9	402±9.5	141	65
S5	15±0.5	57±4.8	488±11.0	134	62
S6	17±0.8	20±1.2	448±10.8	80	39
S7	118±4.7	73±6.1	420±9.3	255	117
S8	96±3.9	65±5.1	525±12.4	230	107
S9	104±4.2	23±1.8	196±4.2	153	70
S10	129±5.2	52±4.3	376±7.3	234	108
S11	23±1.0	18±0.7	208±5.1	65	30
S12	56±0.8	70±5.8	398±7.2	187	86
S13	17±0.8	35±2.4	264±6.2	89	41
S14	16±0.6	41±3.0	303±7.3	99	46
S15	188±5.5	22±1.4	239±3.8	238	110
Min.	15±0.5	20±1.2	170±4.8	65	30
Max.	188±5.5	73±6.1	525±12.4	255	117
Mean	*60±2.6*	*45±3.6*	*324 ±6.8*	*150*	*69*

Variation in the radioactivity concentrations has been observed for different locations. Activity concentrations in all samples, were in the order $^{40}K > ^{232}Th > ^{238}U$ in almost all the soil samples with wide variation in the sediments samples. ^{40}K prevails over the other radioisotopes, is due to the fact that,^{40}K is mostly abundant in all global rocks and in most light minerals(Brai, Hauser, Bellia, Puccio, & Rizzo, 1995; Radi Dar & El-Saharty, 2012).^{232}Th was observed to be higher than ^{238}U in all soil samples. This is simply because ^{232}Th is insoluble in natural environment and preferentially accumulates in a phase relative to ^{238}U(Alfonso *et al*., 2014; Ravisankar *et al*., 2015).

The relatively higher activity values for ^{238}U than ^{232}Th observed in sediments could be explained due to probable transport of uranium mines from the neighboring country (Niger) in to the river. It could be also due to intense use of agrochemicals and chemical fertilizers for agricultural practice along the coastal areas of the river.Some of these chemicals contain minerals with high concentration of radioactive materials such as phosphate fertilizers which contained isotopes of uranium in high concentrations(Khan, Khan, Tufail, Khatibeh, & Ahmad, 1998).Table 3 shows a comparison between measured concentration of radionuclides of this study with that of other countries for soil and sediment.

Table 3: Activity concentration for this study compared with that of other countries

S/N	Country	Type of sample	Activity concentrations ($Bqkg^{-1}$)			Reference
			^{238}U	^{232}Th	^{40}K	
1	River Kaduna, Nigeria	Soil	-	18.76	1168.13	(Abdullahi, Mohammed, & Iheakanwa, 2013)
2	Greater accra, Ghana	Sediment	22.04	108.60	29.78	(Amekudzie *et al*., 2011)
3	Shango river, Bangladesh	Soil	37.9	65.5	272	(Chowdhury *et al.,* 1999)
4	Karnataka	Soil	35.0	29.8	117.5	(Narayana *et al*., 2001)
5	North east coast, Tamilnadu	Sediment	8.39	24.52	274.87	(Ramasamy, Senthil, Meenakshisundaram, & Gajendran, 2009)
6	Oman	Sediment	11.83- 22.68	10.7–25.2	222.89–535.07	(Tari, Zarandi, Mohammadi, & Zare, 2013)
7	Albania	Sediment	8–27	13–40	266–675	(Narayana *et al*., 2001)
8	Spain	Sediment	77–6401	12–63	–	(Radhakrishna, Somashekarappa, Narayana, & Siddappa, 1993)
9	Algeria	Sediment	11–25	6–32	56–607	(Benamar, Zerrouki, Idiri, & Tobbeche, 1997)
19	River Yobe	sediment	60.34	45.19	324.04	Present work
20	River Yobe	Soil	32.47	36.69	395.21	Present Work
21	Worldwide	-	**30.00**	**35.00**	**400.00**	(UNSCEAR, 2000)

Evaluation of Radiological Hazard

Radium Equivalent (Ra_{eq})

Sediment sands from rivers are used with other raw materials for buildings and other civil construction works by the riverine dwellers. The radioactivity from ^{238}U, ^{232}Th and ^{40}K are usually contained in these materials. Hence the radiological indices can be used to assess radiation exposure hazards as a results ofradioactivity due to the radionuclides present (Ravisankar *et al.,* 2015). Radium equivalent is introduced to represent the specific activities of ^{238}U, ^{232}Th and ^{40}K by a single quantity (Radhakrishna et al., 1993). Equation 3 was used to estimate the radium equivalent.

$$Ra_{eq} = (A_U + 1.33A_{Th} + 0.077A_K) \text{ Bq kg}^{-1} \quad (3)$$

where A_U, A_{Th} and A_K are the specific activity concentration of ^{238}U, ^{232}Th and ^{40}K (Bq kg^{-1}), respectively. It has been assumed here that 4810 Bq kg^{-1} of ^{40}K or 259 Bq kg^{-1} of ^{232}Th or 370 Bq kg^{-1} of ^{238}U present the same gamma dose rate. The radium equivalent (Ra_{eq}) in these samples ranged from 69Bq kg^{-1} (S11) to 151Bq kg^{-1} (S7) with a mean value of 106Bq kg^{-1} for soil samples as shown in Table 1. However, the equivalent activity of 65Bq kg^{-1} (S11) to 255Bq kg^{-1} (S8) with mean of 150Bq kg^{-1} was obtained for the sediment samples as shown in Table 2 which are found to be lower when compared with the referencelevel of 370 Bq kg^{-1}(Beretka & Mathew, 1985). It further indicates insignificant radiological hazards associated with the soils and sediments from the river. The result of this study is slightly higher than the mean value of 106 Bq kg^{-1} obtained by (Ravisankar et al., 2015).

Absorbed Dose Rate (D_R)

It is necessary to estimate the amount of radiological risks in the soils and sediments as is delivered externally to the public when used along with building materials. Average values of activity do not give the true radiation hazard associated with radionuclides. To evaluate the radiation hazard associated with natural radioactivity in the soils and sediments, absorbed dose rates in air was estimated. UNSCEAR has converted the specific activity of ^{238}U, ^{232}Th and^{40}K in to doses by conversion factor 0.462, 0.604 and0.0417respectivelyanddoserate (D_R) was calculated using equation 4.

$D_R = (0.462A_U + 0.604A_{Th} + 0.0417A_K)$ nGy h^{-1} (4)

The range of absorbed dose rate in air due to natural radionuclides is from 32 to 72nGy h^{-1} with the mean value of 50 nGy h^{-1} for soil samples and from 30 to 117nGy $h^{-1}$with mean value of 69nGy h^{-1} for sediment samples as shown in Table 1 and 2 respectively. The mean value of the absorbed dose rate in sediment samples is slightly above the world reference value of 59 nGyh^{-1}(UNSCEAR, 2000) but lower than that 750 nGy h^{-1} obtained by Chowdhury *et al.*, (1999) in River Kaduna, Nigeria.

Annual Effective Dose (AED)

The outdoor annual effective dose in mSv y^{-1} due to the absorbed dose rates in air (AED) was estimated using the following formula (UNSCEAR, 2000).

$$AED = D_R(nGY\ h^{-1}) \times 8760h \times 0.2 \times 0.7 \times SvGy^{-1} \times 10^{-6} \quad (5)$$

where, 0.7 SvG y^{-1} and 0.2 are conversion coefficient and outdoor occupancy factor respectively.

In Table 4 and 5, the AED values for the soil and sediment samples are presented. The measured values here ranged between 0.038 and 0.145 with a mean value of 0.085 mSv y^{-1} for soil samples and between 0.040 and 0.089 with a mean value of 0.062 mSv y^{-1} for sediment samples. The mean valuesof AED for this study is considered normal for background radiation (UNSCEAR, 2000).(Al-Trabulsy, Khater, & Habbani, 2011) reported mean annual effective dose of 0.056 mSv y^{-1}in sediments of Saudi coastline of the Gulf of Aqaba which is slightly below the value obtained for this study.

ANNUAL GONADAL DOSE EQUIVALENT (AGDE)

Radiation dose received annually by the population which account for the significant dose to the reproductive organ (gonad) is represented by an index annual gonadal dose equivalent (AGDE) (Ravisankar et al., 2015).The AGDE due to the specific activity of ^{238}U, ^{232}Th and ^{40}K was estimated using equation 6(Merdanoğlu & Altınsoy, 2006).

$$AGD(\mu Svy^{-1}) = 3.09A_U \times 4.18A_{Th} \times 0.314A_K \quad (6)$$

The values of AGDE are presented in Table 4 and 5. The average values of AGDE, was estimated to be 472 Sv y^{-1} and 345 Sv y^{-1} for soil and sediment samples respectively. In general, these average values are below the recommended safety limits, thus hazardous effects due to emission from these radionuclides are negligible.

Table 4: Radiological parameters for soil samples in river Yobe

Sample ID	AEDE (mSv $y-^{1}$)	AGDE (Svy$-^{1}$)	RI (I)	ELCR $\times10-^{3}$
S1	0.056	309	0.720	0.197
S2	0.072	395	0.907	0.252
S3	0.062	338	0.790	0.216
S4	0.080	446	1.034	0.282
S5	0.077	433	1.002	0.271
S6	0.048	275	0.618	0.169
S7	0.145	795	1.805	0.506
S8	0.132	729	1.654	0.461
S9	0.087	479	1.066	0.306
S10	0.133	734	1.650	0.467
S11	0.038	211	0.478	0.132
S12	0.106	587	1.350	0.372
S13	0.051	283	0.653	0.178
S14	0.057	315	0.730	0.199
S15	0.136	747	1.645	0.477
Min.	0.038	211	0.478	0.132
Max.	0.145	795	1.805	0.506
Mean	0.085	472	1.073	0.299

Table 5: Radiological parameters for sediment samples in river Yobe

Sample ID	AEDE (mSv y$-^{1}$)	AGDE (Svy^{-1})	RI (I)	ELCR $\times10^{-3}$
S1	0.058	330	0.755	0.204
S2	0.066	370	0.844	0.230
S3	0.064	358	0.822	0.224
S4	0.057	324	0.741	0.201
S5	0.043	238	0.552	0.152
S6	0.061	346	0.781	0.213
S7	0.070	397	0.896	0.244
S8	0.089	500	1.140	0.310
S9	0.067	375	0.861	0.233
S10	0.051	283	0.651	0.177
S11	0.040	225	0.514	0.141
S12	0.069	387	0.884	0.240
S13	0.051	287	0.659	0.180
S14	0.069	378	0.845	0.242
S15	0.069	375	0.883	0.242
Min.	0.040	225	0.514	0.141
Max.	0.089	500	1.140	0.310
Mean	0.062	345	0.788	0.216

Representative Index (I_γ)

The emission of gamma radiation depends on the dose criterion and the quantity of the sediment used in the construction materials (NEA-OECD., 1979). Gamma representative index for all samples were computed from the equation:

$$I_\gamma = \left(\frac{A_U}{300} + \frac{A_{Th}}{200} + \frac{A_K}{3000}\right) \quad (7)$$

The values of I_γ for soil and sediment samples are given in Tables 4 and 5 above. Representative index values ranged from 0.478 to 1.805 with mean value of 1.073 and from 0.514 to 1.140 with mean value of 0.788 for soil and sediment samples respectively. This index must be lower than unity to keep the radiation hazard insignificant. However, a mean value of 1.073 obtained in this study is slightly higher than the reference level of 0.5 (UNSCEAR, 2000). Dynamic movement of finer sediments from coastal area may resulted to higher values of Iγ at some locations.

Excess Lifetime Cancer Risk (ELCR)

The probability of an individual developing lung cancer due to gaseous exposure over projected intakes from radionuclides of radon and its progenies is estimated using the index excess lifetime cancer risk (ELCR). The ELCR was estimated using equation 8:

$$ELCR = AEDE \times DL \times R \quad (8)$$

Where, DL, AED and RF are the average lifetime duration (70 y), gross annual effective dose, and fatal risk per Sievert (Sv^{-1}), respectively. In this study RF is assumed to be 0.05 Sv^{-1} as per (ICRP, 2000).From Table 4 and 5, the estimated ELCR average values are 0.299 and 0.216 for soil and sediment sample respectively. These values are within the range of the world average value of 0.254(UNSCEAR, 2000). The higher values of ELCR noted in some locations may be attributed to the higher concentrations of radionuclides in the locations. The mean values of ELCR for soils and sediments in River Yobe are found to distinctly lower than the recommended limit of 0.0029 for general public (UNSCEAR, 2000).

CONCLUSION

Gamma spectroscopy technique using NaI(Tl) detector was used to determine the concentrations of naturally occurring radionuclides of uranium, thorium and potassium in River Yobe. A total of 30 samples of soil and sediment samples were collected within and along coastal area of the river. In the present study, arithmetic means of activity concentrations of 23$\pm$1.5, 36$\pm$2.5 and 395$\pm$9.1Bq kg^{-1} for ^{238}U, ^{232}Th and ^{40}K in soil samples respectively, and 60$\pm$2.6, 45$\pm$3.6 and 324$\pm$6.8Bq kg^{-1} for ^{238}U, ^{232}Th and ^{40}K in sediments samples respectively, are obtained. The values obtained in some cases, slightly exceed the worldwide average values of 30 Bq kg^{-1} (^{238}U), 35 Bq kg^{-1} (^{232}Th) and 400 Bq kg^{-1} (^{40}K).

Radiological hazard parameters due to radiation exposure were estimated based on the specific activity concentrations of^{232}Th,^{238}U, and ^{40}K. The results show that the values of radiation hazards parameters are within the worldwide acceptable limits. This mean that the soils and sediments from this river doesn't pose any radiological hazards to the nearby communities/environment and can be safely use for construction of houses and other civil structures. Nevertheless, health hazard due to emission from the natural radionuclides within the soils and sediments of River Yobe is considered normal from a radiological health point of view.

Conflict of Interest

The authors declare no conflict of interest

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