EFFECT OF GRAIN SIZE ON RADIONUCLIDE CONTENTIN SEDIMENT SAMPLES FROM KOLO CREEK, BAYELSA STATE, NIGERIA

Abstract

Abstract

The effect of grain sizes on radionuclide concentration in soil and sediment samples from Kolo creek, Bayelsa State was investigated using gamma spectroscopy. Eight (8) samples of sediment were collected around the oil spill site of the creek. All the samples were separated into four different grain sizes, A (0.5mm), B (1mm), C (1.5mm) and D (2mm), making a total of 32 sediment. The activity concentration in sediment samples of grain sizes 0.5 mm, 1.0mm, 1.5mm and 2mm were determined. In sediment samples of grain sizes 0.5mm(A), ^{226}Ra activity concentration ranges from 2.24±1.54 Bq/kg (Imiringi) to 20.03±2.43Bq/kg (Otuasega 2), while that of ^{232}Th and ^{40}K varies from 3.21±1.01 Bq/kg (Otuasega 2) to 5.59±1.32 Bq/kg (Ibelebiri 1) and 24.46 ± 4.06 Bq/kg (Imiringi 2) to 795.99 ± 6.20 (Kolo) respectively. For grain size of 1.0mm (B) the activity concentration of ^{226}Ra varies from 2.66±1.30 Bq/kg (Ibelebiri 2) to 26.64±4.23Bq/kg (Emeyal) while that of ^{232}Th and ^{40}K varies from 2.19± 0.95 Bq/kg (Imiringi) to 33.47±3.97 (Emeyal) and 43.38 ±3.00 Bq/kg(Ibelebiri 2) to 739.21±6.20 Bq/kg (Kolo) respectively.The mean activity concentrations of ^{226} Ra, ^{232}Th and ^{40}K in sediment samples are 14.68±3.4, 8.49±1.6 and 189.1±4.0 Bq/kg) respectively. The result obtained shows there was no clear trend in variation of activity concentration with grain sizes. The mean values obtained are below the world average of 35, 30 and 400 Bq/kg for ^{226} Ra, ^{232}Th and ^{40}K for grain sizes of 0.5, 1.0, 1.5 and 2.0 mm respectively in all the communities except samples from Kolo that recorded 471.36±6.12 to 795.99±6.44 Bq/kg in all the grain sizes. Radiological risk parameters such as Absorbed Dose Rate, Annual Effective Dose Equivalent, Annual Gonadal Dose Equivalent, Annual Utility Index, Radioactivity Level Index, Hazard Indices and Excess Life Cancer Risk were estimated and values were found to be within the word average. From this study, the sediment of the given grain sizes will pose no radiological health risk if used in farming and in building construction.

1. Introduction

Man is exposed to varying degrees of radiation on earth, through the air we breathe, the soil we use for farming and construction, mining of minerals, sediments we use for building, even the food we consume [1].Despite efforts to ensure safety, radionuclide materialsare~~is~~ introduced into land and water environment of coastal areas which are mainly network of rivers and creeks through leaks, mishandling of equipment, improper discharge, loss and theft [2], Following different pathways through erosion, run-off, flooding, wind etc, large quantities~~y~~ of radionuclides may end up in~~at~~river sediments and farm lands.

However, the exposure to radiation is not limited to internal exposure from the consumption of terrestrial and aquatic foods alone.,~~S~~sediments found in creeks and rivers with high radionuclide concentration used as building material have~~s~~ the probability of increasing external exposure

level. It has been studied that the highest radionuclide content is found in building materials such as sand, stone, bricks and sediments [3], and their concentration are widely distributed in the environment which may vary from one place to another based on geological setting [4].

The distribution of grain sizes in soil is important characteristic factor which can influence the radionuclide distribution in the environment during transport process. Sediments from water bodies (creeks, rivers etc) are made of minerals of different sizes of grain which may serve as a reliable indicator of radionuclide pollution when deposited, and may emit gamma radiation which could be fatal if of high concentration when used in construction of buildings [5].The predominant radionuclides~~mostlyfound~~ are ~~thatof~~ Uranium-238, Thorium-232 series and their progenies and Potassium-40.~~whichmay be of potentialthreatiffound in high concentration,~~It~~it~~ is therefore imperative for proper environmental monitoring to know the radiological status of soil and sediment and its associated risks.

Recent radiological studies revealed high gamma concentration on sediments in Nigeria around oil and gas production facilities and their environments, hence study of radionuclide distribution wasrequiredtoprovides knowledge on the radiological implication of exposure and irradiation to various internal organs of the body [6].

The activity concentration of naturalradionuclides in river sediment depends on mineralogical features in thecatchment area and the chemistry of the river as a whole[7]. The majorsources of natural radionuclides in sediments have differentorigins. These include weathering and recycling ofterrestrial minerals and rocks (igneous or metamorphic) containing ^{40}K and radionuclides of the uranium and thorium radioactive series,rainfall and other depositional phenomena such as gravitationalsettling and precipitation. In stream sediments U and Th maybe found incorporated into the existing minerals or they may beadsorbed directly from river water onto clay minerals or organic debris. Occasionally, U may be removed from river water to sedimentsdirectly if reducing bottom conditions exist [8].

Artificial radionuclides can be introduced into rivers for directand indirect inputs. Directly through the aqueous discharges fromnuclear installations and indirectly fromwash-off of land depositedactivity within the river catchment following nuclear weapontesting or nuclear accidents. Most of the radioactivity detectedposited onsurface soils, depending on the radionuclide's geochemistry, iswashed out by rains and drained in to the rivers. After reaching theriver ecosystem, radionuclides may be transferred through thewater-sediment-biota pathways [9] to humans, by using the river water as drinking water orfor irrigation and~~by~~ the consumption of contaminated fish.

River sediments, consisting of mineral particles with differentsizes, are considered long term reliable indicators of river pollutionby radionuclides because water pollution components are depositedin the sediments. Long-term radioactive pollution may accumulateand whenever the sediments are re-suspended theradionuclides re-enter the sediment-biota chain [5].Therefore, the

knowledge of the concentrations and distribution ofthe radionuclides in the river sediments areofgreatinterestsinceitprovides useful information on thebackgroundandonthe temporalchanges in radionuclide activity concentrations within theriver.

The main objective of this study is to assess, the activity distribution of natural ^{228}Ra, ^{226}Ra, ^{40}K in sediments collected from oil spillRiversediment from oil spill areas of the creek and the influence of the sediment particle sizes on radionuclidesconcentrations. Besides, the knowledge of radionuclidesconcentrations and distribution in River sediments can beuseful for the radiological mapping of the studied area.Bottom sediments consist of particles that have been transported by water, air or glaciers fromthe sites of their origin in a terrestrial environment and have been deposited on the floor of ariver, lake, or ocean [5]. In addition to these particles, bottom sediments will contain materialsprecipitated from chemical and biological processes. Natural processes responsible for theformation of bottom sediments can be altered by anthropogenic activities. Many man-madewastes have entered bodies of water through atmospheric deposition, runoff from land, ordirect discharge into the water. Most hydrophobic organic contaminants, metal compounds, andnutrients, which enter the water attachtobecomeassociatedwith particulate matter. This particulatematter then settles and accumulates in the bottom sediments. Under certain conditions thecontaminants in the bottom sediments may be released back into water or enter the food chain [8].

Consequently, bottom sediments are a sink as well as a source of contaminants in the aquaticenvironment. These contaminants may pose a high risk to the environment on a large scale andhence need to be monitored at regular intervals. Environmental monitoring includes samplingand analyses of the sediments based on grain sizes is of great important. Hence the need for this research work.

2. Materials and Methods

2.1 Study Area

Kolo Creek is situated in Ogbia Local Government Area of Bayelsa State, in the Niger Delta. The study area lies within Latitudes $4^{0}47^{1}$ 40 and $4^{0}56^{1}3^{11}$ N and Longitudes $6^{0}19^{1}15^{11}$ and $6^{0}25'8''$E , Northwest of Yenagoa, within the lower delta plain. It is a non-tidal freshwater environment that empties into the river Nun [10]. It is host to oil and gas fields with noticeable presence of oil exploration and related activities that have attracted the influx of people and businesses. It has a history of oil spillage that has affected farmlands and sources of domestic water of the inhabitants. It is also host to the Kolo creek flow station and a gas turbine plant which supplies electricity to Neighboring communities and parts of the state. The inhabitant is of Ogbia (Ijaw) extraction whose major occupations are farming of cassava, plantain, banana, coco yam, sugarcane and fishing.

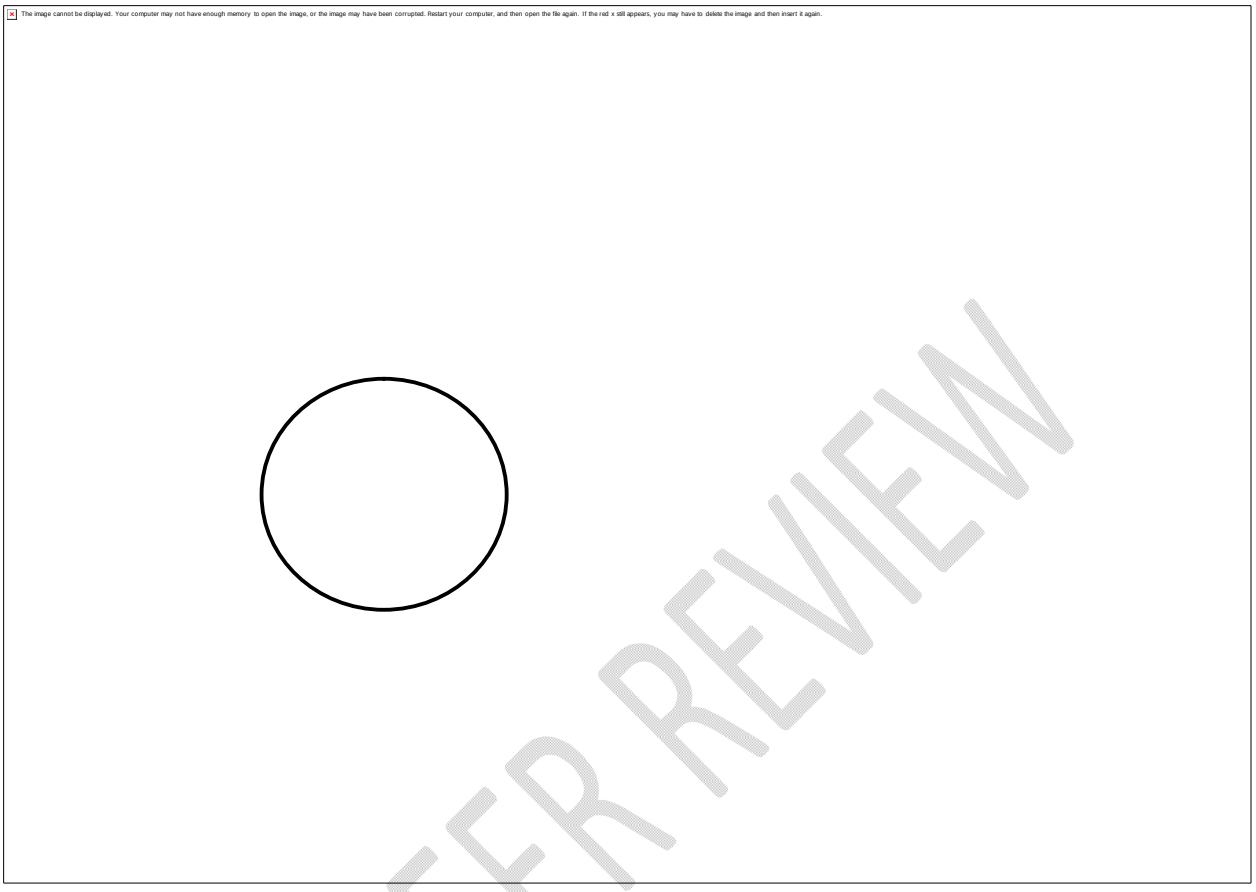

Fig. 1: Study Area (Shell, 2004).

Twelve (12) samples of sediment and soil samples were collected in five (5) communities (Immiringi, Kolo, Ibelebiri,Emeyal And Otuosega) of the study area. Soil samples were collected at a depth of 5cm from the ground surface using a hand-held auger, sediment samples were collected at low tide from the Creek. All the samples were put in a black cellophane bag that wa~~i~~s well labeled. The samples were air dried for two weeks and debris removed before taking them to radiation laboratory. Each sample was separated into four different grain sizes: 0.5mm, 1.0mm, 1.5mm and 2mm and labeled A, B, C and D respectively by passing them through a mesh. The 48 samples were then weighed and filled into Marinelli beakers with labels and sealed to avoid the escape of radon (^{222}Rn and ^{220}Rn) [11] and then stored for about a month, in order to reach the radioactive equilibrium between^{222}Rn with its parent,^{226}Ra (secular equilibrium) before gamma ray spectroscopy was done.

2.2Gamma ray analysis

The samples were analyzed at Radiation Laboratory of the department of Physics, Federal University of Agriculture, Abeokuta, Ogun State. Gamma Ray Spectrometry using a thallium activated 3”x3” Sodium iodide [NaI(TI)] detector connected to ORTEC 456 amplifier was used.

The detector, enclosed in a 100mm thick lead shield, was connected to a computer program SAMPO 90 window that matched gamma energies to a library of possible isotopes. Since the accuracy of the quantitative measurements is dependent on the calibration of the spectrometry system and adequate energy. Background measurement and efficiency calibration of the system was made possible using Cs -137 and Co-60 standard sources from IAEA, Vienna. Spectrum were accumulated for background for 29000s at 900volts to produce strong peaks at gamma emitting energies of 1460 keV for ^{40}K; 609 keV of 214 Bi and 911 keV of ^{228}Ac, which were used to estimate the concentration of ^{238}U (^{226}Ra) and ^{232}Th, respectively. The energy resolution of the detector using Cs -137 and Co-60 standards is 39.5% and 22.2% respectively while the activity of the standards at the time of calibration is 25.37 KBq for Cs - 137 and 4.84 KBq for Co- 60. The background spectra, measured under the same conditions for both the standard and sample measurements, were used to correct the calculated sample activities concentration in accordance with Arogunjo et al., [12]. The activity concentration (C) in Bq/kg of the radionuclides in the samples was calculated after subtracting decay correction using the expression:

$$Cs = \frac{NE_\gamma}{\varepsilon E_\gamma x M_v x t_c x P_\gamma} \quad (1)$$

Where Cs= Sample concentration, NEγ= net peak area of a peak at energy, εEγ= Efficiency of the detector for a γ-energy of interest, Mv=Sample volume, tc= total counting time, Pγ=Emission probability of radionuclide of interest.

2.3 Radiological parameters

2.3.1 Radium equivalent (Raeq)

Due to non- uniformity of radionuclide distribution in a material which contains ^{226}Ra, ^{232}Th, ^{40}K, Radium equivalent activity concentrations are employed to represent the concentration of radionuclides in a material. It represents the net effect of radionuclide present in a material. It is determined by to the equation [14].

$$Raeq = A_{Ra} + 0.143A_{Th} + 0.077A_K \quad (2)$$

Where A_{Ra}, A_{Th} and A_K are activity concentration of ^{226} Ra, ^{232}Th and ^{40}K in Bq/kg respectively assuming 370Bq/kg of ^{226} Ra, 259 Bq/kg of ^{232}Th and 4810 Bq/kg of ^{40}K that will produce the same gamma dose rate.

2.3.2Absorbed Dose Rate (DR)

For a uniform radionuclide distribution, the absorbed dose rate due to gamma radiation in air 1meter above the ground for ^{226} Ra, ^{232}Th and ^{40}K isa measure of the energy deposited in a medium by ionizing radiation from the nuclides. The conversion factor for a unit activity concentration for dry weight of the radionuclides is 0.462 nGyh^{-1} for^{226} Ra , 0.604 nGyh^{-1} for ^{232}Th and 0.042 nGyh^{-1} for ^{40}K. The value is determined by the equation [15].

$$D(nGh^{-1}) = 0.462A_{Ra} + 0.604A_{Th} + 0.042A_K \quad (3)$$

Where $A_{Ra,}$ $A_{Th}$and $A_{K,}$ represents the activity concentration of ^{226} Ra, ^{232}Th and ^{40}K respectively.

2.3.3Internal hazard index (H_{in})

This represents the internal radiation. It is important due to the present of radon gas and its short-lived products and the hazard they pose to the respiratory organ [16]. For it to be insignificant, the index must be less than unity. It is determined according to the equation:

$$H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1 \quad (4)$$

Where A_{Ra}, A_{Th} and A_K are the activity concentration of ^{226} Ra, ^{232}Th and ^{40}K in Bq/kg respectively

2.3.4 External Radiation Index (H_{ex})

This value also must be less than unity for it to be insignificant. Both internal and external hazard index is determined from Raeq expression through the superposition that the maximum value will be equal to 1 corresponds to the upper limit of Raeq (370 Bq/kg).The external radiation hazard index is determined according to the equation [14].

$$H_{Ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1 \quad (5)$$

2.3.5 Annual Effective Dose Equivalent (AEDE)

It represents a measure of deterministic or stochastic risk due to irradiation. This parameter converts the absorbed dose in air given in $nGyh^{-1}$ with a factor of 0.7 $SvGy^{-1}$ to effective dose rate in milliServet per year ($mSvyr^{-1}$). The time of stay is 20% of 8760 hr in a year for indoor annual effective dose and 80% for outdoor annual effective dose. The value should not exceed 1mSv/yr [15], the world average value is 0.48mSv/yr. it is determined according to the equation [15].

$$AEDE = DR(nGyh^{-1}) \times 8760hy^{-1} \times 0.7SvGy^{-1} \times \frac{10^3 mSv}{10^9 nGy} \times 0.2 \quad (6)$$

2.3.6 Annual Gonadal Dose (AGD)

The organs of interest are the gonad, active bone marrow and the bone surface cells. They are radiosensitive and when affected may cause significant damage. High values of AGDE can cause damage to the red blood cells and bone marrow due to their sensitive nature, which may result to cancer [6].

The annual gonadal dose equivalent due to ^{226} Ra, ^{232}Th and ^{40}K are determined by the equation [17].

$$AGDE(mSvy^{-1}) = 3.09A_{Ra} + 4.18A_{Th} + 0.0314A_K \quad (7)$$

Where A_{Ra}, A_{Th} and A_K are activity concentration of ^{226} Ra, ^{232}Th and ^{40}K in Bq/kg respectively.

2.3.7 Gamma Representative Index

Also called gamma radioactivity level index, is concerned with the radioactivity associated with different concentration of some specific nuclides. It is given by Eshiemomoh et al., [14].

$$RLI = \frac{A_{Ra}}{150Bqkg^{-1}} + \frac{A_{Th}}{100Bqkg^{-1}} + \frac{A_K}{1500BqK^{-1}} \leq 1 \quad (8)$$

Where A_{Ra}, A_{Th} and A_K are the activity concentration of ^{226} Ra, ^{232}Th and ^{40}K in Bq/kg respectively .RLI ≤ 1 corresponds to AEDE ≤ 1mSv/yr.

2.3.8 Activity Utilization Index (AUI)

This is used as criteria for building construction, to calculate the dose rate in air arising from ^{226} Ra, ^{232}Th and ^{40}K, since sediments and soil are used in building construction. A wall made up of soil (sandy, muddy or coarse grains) can be a source of radiation and can also serve as a shield against outdoor radiation [15].

The Activity Utilization Index is defined by applying appropriate conversion factors [19].

$$AUI = \left(\frac{A_{Ra}}{50}\right) F_{Ra} + \left(\frac{A_{Th}}{50}\right) F_{Th} + \left(\frac{A_K}{50}\right) F_K \leq 2 \quad (9)$$

Where F_{Ra}(0.462), F_{Th}(0.604) and F_K(0.041) represents the various fractional contribution to the total gamma dose in air from actual concentration of ^{226} Ra, ^{232}Th and ^{40}K. The recommended safe limit is 2.

2.3.9 Excess Life Time Cancer (ELCR)

At certain exposure level (rate), there is the possibility of developing cancer over time from exposure. The excess life time cancer risk gives that probability.

The ELCR is calculated by Degerlier*et al.*,[20].

$$ELCR = AEDE \times DL \times RF \quad (10)$$

Where AEDE, DL and RF are the annual effective dose equivalent, duration of life (life expectancy of 70yrs) and fatal risk factor per Sievert. For stochastic effect a value of $0.05Sv^{-1}$ was given by ICRP 60 for the public [21].

3. Results

Table 1: Activity concentration of Radionuclides according to their grain size and radium equivalent in sediment samples

S/N	Sample location	GPS reading	Grain size	Activity Concentration ($Bqkg^{-1}$)			Raeq($Bqkg^{-1}$)
				^{226}Ra	^{232}Th	^{40}K	
1	Ibelebiri 1	N4°56′3.2″	A	13.08±3.51	5.59±1.32	69.58±3.46	26.4
		E6°25′8.1″	B	4.40±1.09	3.45±0.74	88.51±4.24	14.7
			C	17.14±2.74	3.11±1.17	97.24±2.74	29.0
			D	5.56±3.54	2.87±1.33	113.25±2.74	18.3
2	Ibelebiri 2	N4°56′05″	A	13.08±2.87	3.70±1.20	55.47±2.74	22.6
		E6°25′7.5″	B	2.66±1.30	5.30±0.81	43.38±3.00	13.5
			C	4.40±1.09	3.45±0.74	39.90±3.54	12.4
			D	4.86±1.23	3.84±0.78	43.38±3.00	13.7
3	Otuasega1	N4°55′6.4″	A	10.19±4.62	4.37±1.52	57.94±3.32	20.9
		E6°23′52.8″	B	17.14±4.03	4.76±1.42	116.17±3.74	32.8
			C	33.93±3.65	3.79±1.35	53.57±3.61	43.4
			D	20.03±3.68	5.30±1.36	39.01±4.00	30.6
4	Otuasega2	N4°55′5.4″	A	20.03±2.43	3.21±1.10	197.69±4.53	39.8
		E6°23′53.6″	B	15.40±3.12	4.18±1.25	196.23±4.30	36.4
			C	7.76±4.35	4.62±1.47	331.61±5.43	39.9
			D	4.86±3.78	4.71±1.37	207.88±3.94	27.6
5	Imiringi 1	N4°52′46′	A	3.24±1.54	3.21±0.88	140.91±4.00	18.6
		E6°22′32.8″	B	2.66±1.81	2.19±0.95	121.99±4.30	15.1
			C	8.45±5.95	2.14±1.72	223.89±3.54	28.7
			D	32.19±3.95	2.19±1.40	60.85±2.83	40.0
6	Imiringi2	N4°52′45″	A	7.76±4.93	4.81±1.57	24.46±4.06	16.5
		E6°22′32.3″	B	17.14±4.03	5.30±1.42	91.42±4.53	31.7
			C	30.45±3.75	4.91±1.37	219.52±5.00	54.3
			D	40.29±2.50	4.67±1.12	76.86±4.42	52.8

7	Emeyal	N4°50′31″	A	13.67±5.59	13.92±5.3	212.53±2.68	49.9
		E6°20′19″	B	26.64±4.23	33.47±3.9	285.32±2.50	96.4
			C	23.76±5.85	26.15±5.3	243.63±3.61	79.9
			D	21.59±5.07	83.20±3.9	96.08±4.15	147.9
8	Kolo	N4°47′40″	A	11.51±3.63	5.39±1.35	795.99±6.44	80.50
		E6°19′15′	B	21.77±4.59	4.62±1.51	739.21±6.20	85.2
			C	9.49±4.70	5.35±1.53	471.36±6.12	53.4
			D	4.81±1.84	3.94±0.96	497.56±5.87	48.7

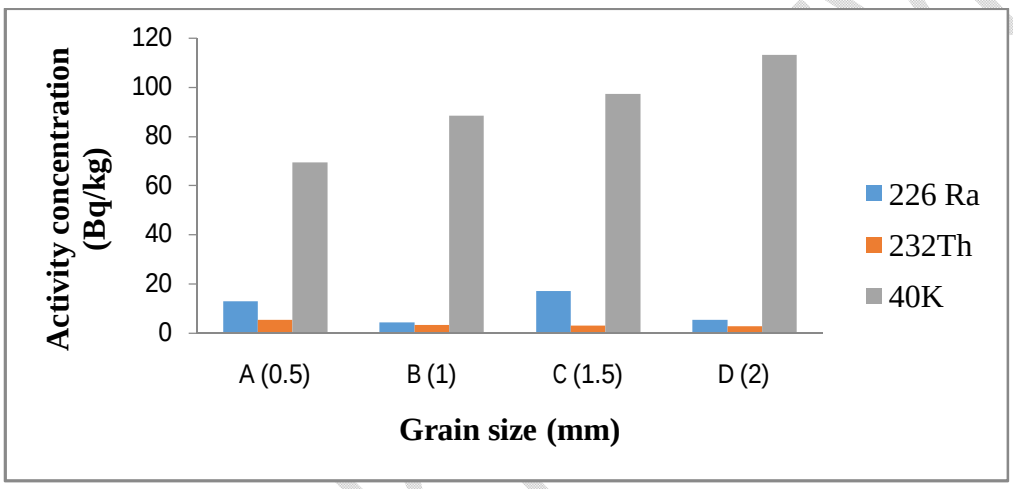

Fig.2:**Variation of activity concentration with grain size for Ibelebiri1 sediment samples**

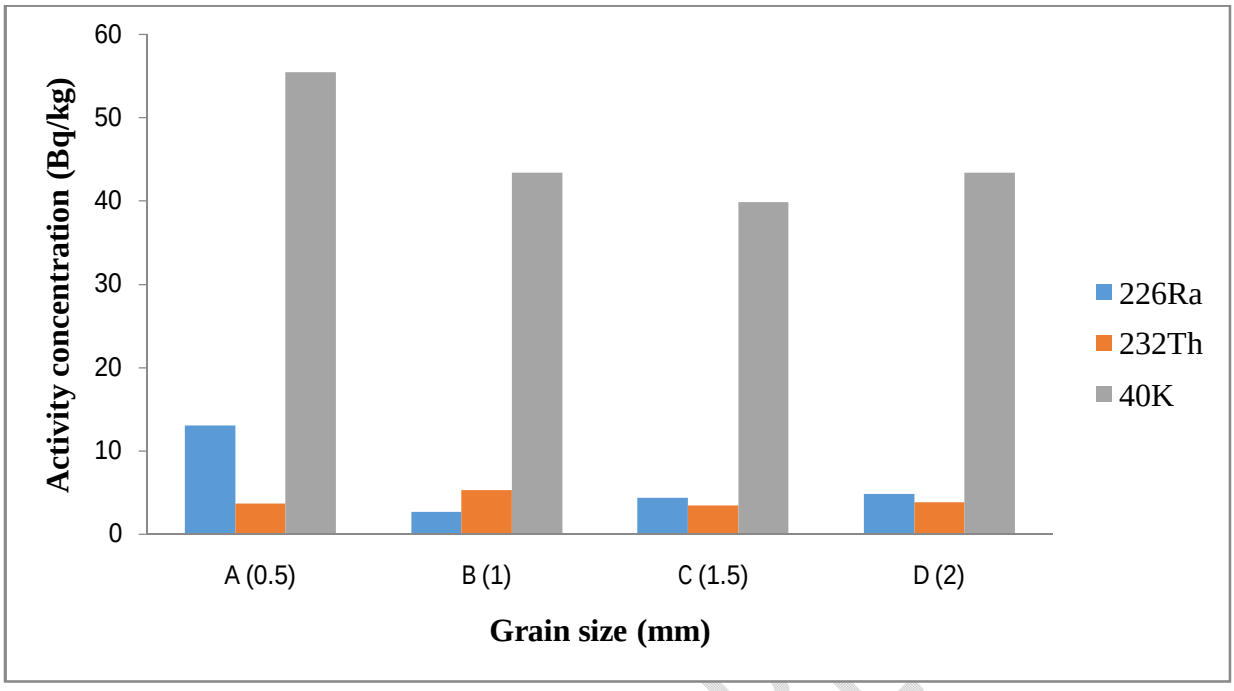

Fig.3:**Variation of activity concentration with grain size forSediment from Ibelebiri 2 samples**

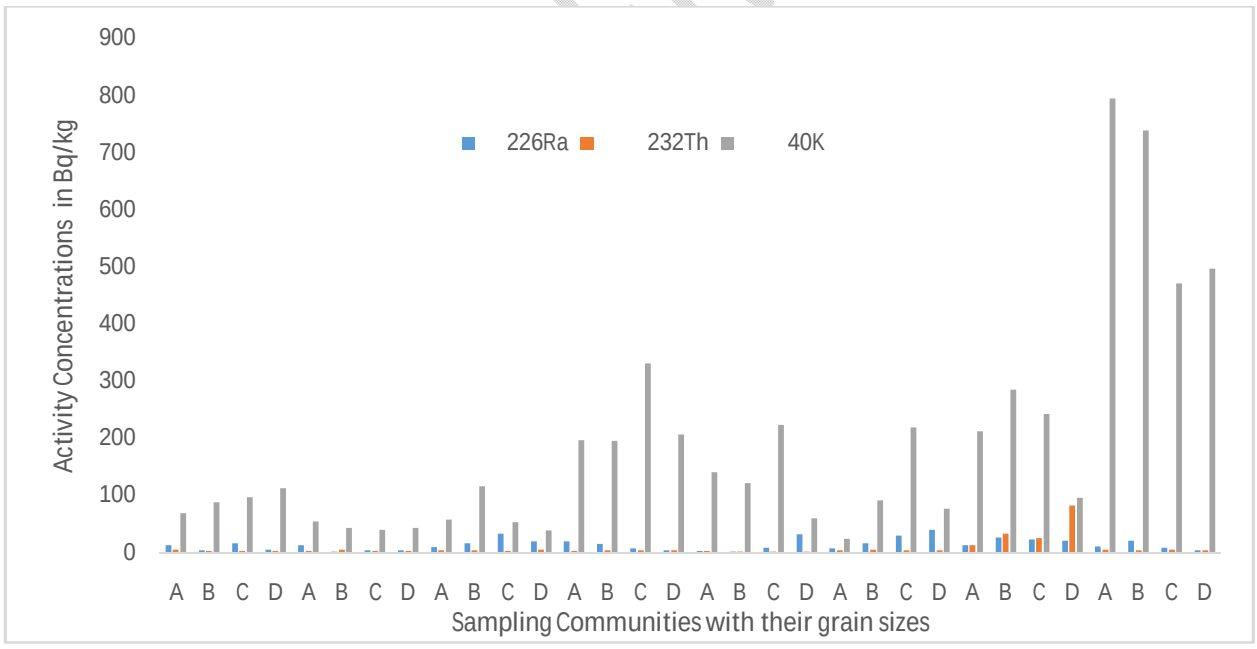

Fig 4: Variations of activity concentration of ^{226}Ra, ^{40}K and ^{232}Th with grain sizes

Table2: Radiological risk parameters in sediment samples from Kolo creek

S/N	Sample location	grain size	DR ($nGyh^{-1}$)	AEDE ($mSvh^{-1}$)	AGD ($mSvh^{-1}$)	AUI	RLI	H_{ex}	H_{in}	ELCR x 10^{-3}
1	Ibelebiri 1	A	12.34	0.015	89.04	0.245	0.189	0.071	0.106	0.053
		B	7.834	0.009	55.80	0.154	0.122	0.043	0.055	0.032
		C	13.88	0.017	96.46	0.275	0.210	0.078	0.124	0.059
		D	9.058	0.011	64.73	0.178	0.141	0.049	0.064	0.038
2	Ibelebiri 2	A	10.60	0.014	73.30	0.211	0.161	0.050	0.096	0.049
		B	6.252	0.008	43.99	0.124	0.099	0.036	0.043	0.028
		C	5.792	0.007	40.54	0.115	0.090	0.033	0.045	0.025
		D	9.058	0.008	44.68	0.126	0.099	0.036	0.050	0.028
3	Otuasega1	A	9.780	0.012	67.94	0.194	0.150	0.056	0.083	0.042
		B	15.67	0.019	109.3	0.311	0.239	0.088	0.135	0.066
		C	20.04	0.024	138.1	0.403	0.299	0.117	0.209	0.084
		D	14.09	0.017	96.24	0.281	0.212	0.082	0.136	0.059
4	Otuasega2	A	19.46	0.024	137.3	0.385	0.297	0.107	0.161	0.084
		B	17.88	0.022	126.6	0.353	0.275	0.098	0.140	0.077
		C	20.30	0.025	147.4	0.399	0.319	0.107	0.128	0.087
		D	13.83	0.017	99.97	0.272	0.218	0.074	0.087	0.059
5	Imiringi 1	A	9.35	0.011	67.67	0.184	0.147	0.050	0.059	0.038
		B	7.675	0.009	55.67	0.151	0.120	0.041	0.048	0.032
		C	14.59	0.018	105.3	0.287	0.226	0.077	0.166	0.063
		D	18.74	0.023	127.7	0.373	0.277	0.187	0.195	0.081
6	Imiringi 2	A	7.517	0.009	51.57	0.149	0.116	0.044	0.065	0.032
		B	14.95	0.018	103.8	0.297	0.228	0.085	0.132	0.063

		C	26.25	0.032	183.5	0.520	0.398	0.146	0.229	0.112
		D	24.66	0.030	168.1	0.491	0.366	0.142	0.251	0.105
7	Emeyal	A	23.61	0.029	167.1	0.468	0.372	0.134	0.171	0.102
		B	44.50	0.055	311.0	0.884	0.705	0.260	0.332	0.193
		C	36.99	0.045	259.2	0.735	0.582	0.215	0.279	0.157
		D	64.26	0.078	444.6	1.283	1.039	0.399	0.457	0.273
8	Kolo	A	41.52	0.051	308.0	0.824	0.661	0.217	0.248	0.178
		B	43.89	0.054	318.6	0.863	0.684	0.230	0.289	0.189
		C	27.41	0.034	199.6	0.538	0.431	0.144	0.169	0.119
		D	25.49	0.031	187.5	0.050	0.403	0.131	0.144	0.108
	MEAN		**19.91**	**0.024**	**140.3**	**0.378**	**0.308**	**0.113**	**0.153**	**0.085**

4. Discussion

In sediment samples of grain sizes 0.5mm(A), ^{226}Ra activity concentration ranges from 2.24±1.54 Bq/kg (Imiringi) to 20.03±2.43Bq/kg (Otuasega 2), while that of ^{232}Th and ^{40}K varies from 3.21±1.01 Bq/kg (Otuasega 2) to 5.59±1.32 Bq/kg (Ibelebiri 1) and 24.46 ± 4.06 Bq/kg (Imiringi 2) to 795.99 ± 6.20 (Kolo) respectively. For grain size of 1.0mm (B) the activity concentration of ^{226}Ra varies from 2.66±1.30 Bq/kg (Ibelebiri 2) to 26.64±4.23Bq/kg (Emeyal) while that of ^{232}Th and ^{40}K varies from 2.19± 0.95 Bq/kg (Imiringi) to 33.47±3.97 (Emeyal) and 43.38 ±3.00 Bq/kg(Ibelebiri 2) to 739.21±6.20 Bq/kg (Kolo) respectively.

For grain sizes 1.5mm (C), ^{226}Ra activity concentration ranges from 4.40±1.09 Bq/kg (Ibelebiri 2) to 33.93± 3.65 Bq/kg (Otuasega 1) while that of ^{232}Th and ^{40}K varies from 2.14±1.72 Bq/kg (Imiringi 1) to 26.15± 5.37 Bq/kg (Emeyal) and 39.90 ± 3.54 Bq/kg (Ibelebiri 2) to 471.36 ± 6.12 (Kolo) respectively. For grain sizes 2.0mm (D) ^{226}Ra activity concentration ranges from 4.81±1.84 Bq/kg (Kolo) to 40.29± 2.50 Bq/kg (Emeyal) while that of ^{232}Th and ^{40}K varies from 2.19±1.40 Bq/kg (Imiringi 1) to 83.20± 3.91 Bq/kg (Emeyal) and 39.01 ±4.00 Bq/kg(Otuasega 1) to 497.56±5.87 (Kolo) respectively.Mean value of ^{226}Ra,^{232}Th and ^{40}K for all sediment samples are 14.68±3.4 Bq/kg,8.49±1.6 Bq/kg and 189.1±4.0 Bq/kg respectively. The results show that only sample with grain size of 2

mm from Imirigi recorded higher value of 40.29 Bq/kg for ^{226}Ra while other values obtained for all the radionuclidesare below their permissible values of 35, 30 and 400Bq/kg. The activity concentration of ^{40}K in samples from Kolo community of varying grain sizes exceeded the permissible limit of 400.0 Bq/kg. However, the variation of activity concentration of radionuclides with grain size though not uniform, increases with increase in grain size in some samples. Figures 2-4 showed the variation of ^{226}Ra, ^{232}Th and ^{40}K with different grain sizes of sediment samples. Activity concentration of ^{40}K were higher in all the grain sizes from all the communities along the Kolo creek.

The average activity concentration values of^{226}Ra ,^{232}Th and ^{40}K obtained in the study area are lower than the average values of 16.82Bq/kg, 32.84 Bq/kg and 743.52 Bq/kg recorded in Bangladesh by Nizam*et al.*,[22],189.62, 53.47 and 725.62 Bq/kg in Ndokwa east of Delta state recorded by Ononugbo and Ofuonye[6]. The radiological risk parameters estimated in the samples were lower than their safe values. The activity utilization index was lower than unity which means that sediment from Kolo creek is suitable for building purposes since the radiological risk of exposure is minimal.

5. Conclusion

Gamma Spectrometry using Sodium Iodide (Thallium) will continue to be popular for delineating the activity concentration of primordial isotopes ^{40}K, ^{232}Th, and ^{226}Ra present in sediment samples from Kolo Creek. Findings shows that the average activity concentrations of ^{40}K increased with increase in grain size in some samples but overturned in samples from Kolo community where ^{40}K values recorded in grain size 0.5 (A) was the highest (795.99 ±6.44 Bq/kg) while ^{226}Ra and ^{232}Th activities varied randomly with grain sizes. The estimated radiological health risk parameters also showed random variation with grain sizes and are within their safe limits.This result showed that the activity concentration of radionuclides in sediment samples from Kolo creek does not depend on grain sizes.

References

[1]. Ademola, J.A. (2008) Exposure to high background radiation level in the tin mining area of Jos Plateau state, *Nigeria Journal of Radiological Protection* 28:93-99.

[2] Olatunde, M. O., Idowu, P. F and Ayodeji O. A. (2011) Natural Radionuclide Concentrations and Radiological Impact Assessment of River Sediments of the Coastal Areas of Nigeria, *Journal of Environmental Protection* 2(4):418-423.

[3] Turtiainen, T., Salahel-Din, K., Klemola, S And Sihvonen, A.P.(2008). Collective Effective Dose by the Population of Egypt from Building Materials, *Journal of Radiological Protection,* 28(2): 223-232.

[4] Iqbal, M., Tufail, M and Mirza, S.M.(2000). "Measurement of Natural Radioactivity in Marble Found in Pakistan Using a NaI(Tl) Gamma-Ray Spectrometer". Technical Note, *Journal of Environmental Radioactivity,* 51(2): 255–265.

[5] Bikit, I., Slivka, J., Veskovic, M., Varga, E., Zikic-Todorovic, N., MrYa, D.andForkapic, S.(2006). Measurement of Danube sediment radioactivity in Serbia and Montenegro using gamma ray spectrometry. *Radiation Measurement*. 41: 477-481.

[6] Ononugbo ,C.P.andOfuonye,I (2017). Natural Radioactivity Levels and Radiation Hazards in Shore Soil and Sediments along the Coast of Ndokwa East, Delta State, Nigeria.*Archives of Current Research International* 9(4):1-13.

[7] Madruga, M.J., Silva, L.,Gomes, A.R. Libânio, A.and. Reis, M.(2014). The influence of particle size on radionuclide activity concentrations in Tejo River sediments. *Journal of Environmental Radioactivity* 132:65-72.

[8] Ovuomarie-Kelvin, S.I., Ononugbo, C.P.andAvwiri, G.O.(2018).Assessment of radiological health risk from gamma radiation level in selected oil spill communities of Bayelsa State; Nigeria. *Current Journal Of Applied Science And Technology.*28(3):1-12.

[9] Akkurt,I.,Mavi, B.,Akyildırım, H.andGünoglu,K.(2009). Naturalradioactivityofcoalsanditsriskassessment.*International Journal of PhysicalSciences*; 4(7):403–406.

[10] Agbalagba, E.O., Avwiri, G.O., Chad-Umoreh,Y.E.,(2012). γ-Spectroscopy measurement of natural radioactivity and assessment ofradiation hazard indices in soil samplesfrom oil fields environment of Delta State,Nigeria. *Journal of Environmental Radioactactivity*. 109:64-70.

[11] Alagoa, E.J (1999) Land and people of Bayelsa State, central Niger Delta, onyema publications, Port- Harcourt. 167.

[12] Suresh, G., Ramasamy, V., Meenakshisundaram, V., Venkatachalapathy, R.andPonnusamy, V. A.(2011). Relationship between the natural radioactivity and mineralogical composition of the Ponnaiyar river sediments. *Indian Journal of Environmental Radioactivity*. 102:370-377.

[13] Anekwe, U. L., Avwiri, G. O and Agbalagba, E. O.(2013).Assessment of Gamma-Radiation Levels in Selected Oil Spilled Areas in RiversState, Nigeria. *Energy Science and Technology*5(1): 33-37

[14]. Eshiemomoh A.O., Avwiri , G.O. and Ononugbo, C.P. (2021). Assessment of Natural Radioactivity and Health Hazards in soils from some selected solid mineral mining sites in Edo-North, Nigeria. *Global Scientific Journals, 9(7):324-338.*

[15] UNSCEAR. (2000). Sources and Effects of Ionizing Radiation. Annex B: Exposures from Natural Radiation Sources. United Nations Scientific Committee on the Effects of Atomic Radiation. Report to General Assembly with Scientific Annexes. United Nations, *New York. 115-116*

[16]Yoshimura, K., Onda, Y.amd Fukushima, T.(2014).Sediment particle size and initial radiocesium accumulation in ponds following the Fukushima DNPP accident. *Scientific Reports*4 :4514.

[17] Arafa, W.(2004). Specific activity and hazards of granite samples collected from the Eastern desert of Egypt, *Journal of Environmental Radioactivity*75:315-322.

[18] Ravisankar, R., Vanasundari, K., Chandrsekaran, A., Rajalakashmi, A., Suganya, M., Vijayagopal, P and Meenakshisundram, V.(2012). Measurement of natural radioactivity in building materialsofTamilnadu, India using gamma ray spectroscopy. *Applied. Radiation and isotope*. 70:699-704.

[19]. Akkurt, I., Altindag,R., Onargan, T., Basyigit, C.,Kilincarsla, S., Kun,M., Mavi, B.andGuney,A.(2007). Construction and Building Material. 21: 20-78.

[20] Degerlier, M., Karahan, G and Ozger, G.(2008) Radioactivity concentrations and dose assessment for soil samples around Adana, *Turkey Jounal of Environmental. Radioactivity*. 99:1018-1025.

[21]. Suresh, G., Ramasamy, V., Meenakshisundaram, V., (2012). Effect of lower grain sized particles on natural radiation level of the Ponnaiyar river sediments. Applied Radiatiation and Isotope 70 (3):556-562

[22] Nizam, Q.M.R., Ginnah, M.A., Rahman, M.M., Kamal,M and Chowdhury, M.I.(2013). Assessment of activity concentration of radionuclides from upper-level sediments in Charfassion Island, Bhola, Bangladesh. *Journal of nuclear and particle physics* 3(3):36-39.