Measurement of Activity Concentrations of ^{40}K, ^{226}RA And ^{232}TH for Assessment of Radiation Hazards from Soil Samples from Oil Mining Lease (OML) 58 and 61, Oil and Gas Producing Areas in The Niger Delta Region of Nigeria

Alao, A.Adewumi[1]

Department of Physics
Federal College of Education (Tech), Omoku, Rivers State, Nigeria
alaodby@yahoo.com

Abstract: ***The analysis of Naturally Occurring Radionuclides (40k, 226Ra and 228Ra) has been carried out in soil samples collected from Oil Mining Lease (OML) 58 and 61 (Oil and Gas Producing Areas) in the Niger Delta Region of Nigeria, using gamma spectroscopy operated on a Canberra vertical high purity coaxial germanium (HpGe) crystal detector. The Activity concentration of the samples ranged from 98.84 ± 18.95 Bqkg-1 to 205.98± 29.06 Bqkg-1 with mean value of 148.10± 30.36 Bqkg-1 for 40K, 11.93± 3.92 Bqkg-1 to 15.41± 6.02 Bqkg-1 with Mean value of 13.28± 4.67 Bqkg-1 for 226Ra, 9.36± 3.63 Bqkg-1 to 14.05± 5.12 Bqkg-1 with mean value of 11.11± 4.13 Bqkg-1 for 228Ra. These values obtained are well within the world ranged and values reported elsewhere in other countries. The External Hazard Index (Hex) ranged from 0.089 to 0.125 with a mean of 0.107, the internal hazard Index (Hin) ranged from 0.121 to 0.165 with a mean of 0.142 respectively. The Radium equivalent activity (Raeq) calculated ranged from 35.01 Bqkg-1 to 46.56 Bqkg-1 with a mean of 40.57 Bqkg-1. The Absorbed dose ranged from 15.44nGyh-1 to 22.44nGyh-1 with a mean of 19.30nGyh-1, while the Effective dose ranged from 0.019 mSvy-1 to 0.027mSvy-1 with a mean of 0.023mSvy-1. These calculated hazard indices are used to estimate the potential radiological health risk in soil and the dose rate associated with it are well below their permissible limit. The soil from the study area provides no excessive exposures for inhabitants and can be used as construction materials and agricultural purposes without posing any immediate radiological threat to the public. However, inhabitants are cautioned against excess exposure to avoid future accumulative dose of these radiations especially from other sources.***

Keywords: Soil, Assessment, Gamma-Spectroscopy, hazard Indices.

1. Introduction

Naturally occurring radioactive materials (NORM) existing in soil could pose potential health risk (Ahmad T.R et al,2009) especially if assisted by natural processes such as weathering, deposition and wind erosion (Elles et al., 1997). NORM can be found in many geological formation and may be brought to the surface during Oil and Gas drilling and abstraction (M.Omar et al, 2004). Human beings are exposed outdoors to the natural terrestrial radiation that originates predominantly from the upper 30cm of the soil (Narayana et al, 1994). Elevated radon and gamma exposures in dwellings are known to be caused primarily by enhanced concentrations of naturally occurring radionuclide in building materials and soil. (Isinkaye and Shitta, 2010). The use of soil as building material could therefore cause radiation exposure to man due to inhalation of gaseous daughters of Uranium and thorium decay series in the indoor air. It can also lead to an external exposure due to gamma radiation from the primordial radionuclide present in the soil. The equilibrium in the environment has become disturbed because of the expansion of technical civilization accompanied by intense application of chemicals (S. Chibowski, et al, 1999). In the second part of our century violent growth of the population has increased food demand, causing intensive use of fertilizer in agriculture. The continuous increase of applied chemicals has produced many problems due to its harmful influence on animals and human beings. Only radionuclide with half-lives comparable with the age of the earth or their corresponding decay products existing in terrestrial materials such as 232Th, 238U and 40K are of great interest. (Senthilkumar B., et al., 2010). Since these radionuclides are not uniformly distributed, the knowledge of their distribution in soil and rock play an important role in radiation protection and measurement. (Rani A, Singhs, 2005). Gamma radiation from these represents the main external source of irradiation to the human body and the concentrations of this radionuclide in soils are determined by the radioactivity of the rock and also nature of the process of the formation of the soils. (Orabi, et al, 2006, Al-Jundia et al, (2003). Therefore, radionuclide in soil generates a significant component of the background radiation exposure to the population (Goddard, C. C, 2002). Because a higher concentration of radioactive substances in the environment is undesirable, this paper presents some investigations of gamma emitting elements in environmental samples like soil.

2. Study Area

The study area lies with latitude 5013c and 5022c N and longitude 6033c E and 6042c North West of the Niger Delta region of Nigeria (UNDP, 2006). It is one of the onshore oil producing area of Rivers State. The area which is one of the highest oil and gas production onshore of Niger Delta has over 900 oil wells with over thirteen active oil fields and playing a host to three multinational companies such as Nigeria Agip Oi Company (NAOC), Total FINA Elf, Shell, (Abali, 2009). The area is criss-cross with network of pipelines carrying either oil or gas to the flow stations from the different oil wells (UNDP, 2006). Gas flaring and oil spillage due to rupture of pipe leakage has been the major environmental pollutant in the area. The study area has topography of flat plains netted in a web of rivers- the Niger, Sombreirao (Nkissa), Orashi and their tributaries as well as dotted creeks. The tertiary lithostratigraphic sequence of the Niger Delta consists in an ascending order of the Akata, Agbada and Benin formations respectively. With the Benin formation making up an overall classic sequence of about 9000-12,000m thick deposits (Ajayi et al, 2009). The paralytic Agbada formation is a sequence of alternating sandstone and shales. Major hydrocarbon accumulations are found in the intervals between the Eocene and the Pliocene. The Lowest unit (the Akata formation) is a uniform marine shale unit that may contain lenses of abnormally over pressured siltstones or fine grained sandstones. Oil and gas occurrence in the Niger delta are concentrated mainly in the sandstones reservoir at various levels of the Agbada formation (Ajayi et al., 2009). Figure 1 is the map of the study area.

Figure 1: Nigeria Niger Delta Region

3. Materials and Methods

Soil samples are usually collected for studying either total deposition or availability of radionuclide to crops grown in cultivated agricultural land. For this study i.e radionuclide availability studies, sample were taken in crops area with a coring tool to a depth range of 0-0.030m. Coring tools of known diameters was used so that the ground area represented by the sample is accurately known; five (5) cores or a total surface area of at least 0.02m2 were taken and composited to make a single sample. Each sample was kept separately to avoid cross contamination. The soil sample was directly dried at room temperature or in an oven at 500C and then grounded and passed through a mesh size of 2mm. The large particles were discarded and the meshed soil were sealed for at least 28 days in plastic containers previously washed and rinsed with diluted sulphuric acid before analysis with Gamma-Spectrometer (IAEA, 1989) The gamma-counting equipment was a Canberra vertical High purity coaxial germanium (HpGe) crystal detector model (NaI(T1)Detector,Model Bircom,Preamplifier Model 2001,Amplifier Model 2020,ADC Model 8075,HVPS Model 3105) enclosed in a 100-mm-lead shield and coupled to a Canberra Multichannel Analyzer (MCA) computer system. The quantification of radionuclide present in soil samples was obtained through accurate energy and efficiency calibration as stated in other works (P.Tchokossa et al, 2011, Shenthilkumar et al, 2010). The MCA was calibrated so as to display gamma photo peaks in the applied energy range for radionuclide of interest identified with reliable regularity. The counting time was 36000 s.

4. Data Presentation

Table 1(a): Sample Collection Plan

S/N	Zone Code	Zones Names
1	A	OMOKU/OBITE/AKABUKA
2	B	OBRIKOM/EBOCHA/MGBEDE
3	C	AHOADA/OKOGBE
4	D	BIG ELELE/UMUDIOGA
5	E	ELELE ALIMINI
6	F	MBIAMA/ENGENNI COMMUNITY

Table 1(b): Geographical locations of Surveyed Soil Samples

Sample Name/ Zone	Sample Type(Soil)	Code	Geographical Location(s)	
			Latitude(0)	Longitude(λ)
1	Soil	SA	05 22.666	06 40.224
2	Soil	SA2	05 20.685	06 40.164
3	Soil	SB	05 27.091	06 41.786
4	Soil	SC	05 03.718	06 35.937
5	Soil	SD	05 11.433	06 47.102
6	Soil	SE	05 03.785	06 44.837
7	Soil	SF	05 03.999	06 29.562

Table 2: Specific Gamma Activity Concentrations of 40K, 226Ra, 228Ra together with Radiation Hazard parameters measured in Soils in all Zones, OML 58 and OML 61, Niger Delta Region of Nigeria

	Soils			Radiation hazard Parameters				
Sample	40K (Bq/kg)	^{226}Ra (Bq/kg)	^{228}Ra (Bq/kg)	D(nGy/hr)	Deq(mSv/yr)	Raeq (Bq/kg)	Hex	Hin
SA	14.79±28.63	15.41±6.02	13.45±6.34	21.76	0.026	46.02	0.124	0.166
SA2	205.98±29.06	13.63±5.12	11.94±4.84	22.44	0.027	46.56	0.126	0.163
SB	159.62±35.97	12.73±3.45	10.15±3.43	18.91	0.023	39.54	0.107	0.141
SC	127.79±34.65	14.54±4.54	14.05±5.12	20.95	0.025	44.47	0.120	0.159
SD	162.65±37.53	9.97±3.77	8.75±2.65	16.93	0.020	35.01	0.095	0.122
SE	134.06±27.86	14.74±5.90	10.07±2.92	18.65	0.023	39.46	0.107	0.146
SF	98.84±18.95	11.93±3.92	9.36±3.63	15.44	0.019	32.93	0.089	0.121
Average	**148.10±30.38**	**13.28±4.67**	**11.11±4.13**	**19.30**	**0.023**	**40.57**	**0.110**	**0.145**

Table 3: Mean calculated radiation hazard indices of all surveyed soil samples for all zones in OML 58 and 61, Niger Delta Region of Nigeria

	Tubers	Radiation parameters			Hazard Indices
Area Code	**Surveyed Area**	**Absorbed dose(D)(nGy^{-1})**	**Effective Dose (msvy^{-1})**	**Hex**	**Hin**
A	OMOKU/ OBITE/ AKABUKA	22.10	0.027	0.125	0.165
B	OBRIKOM/EBOCHA/ MGBEDE	18.91	0.023	0.107	0.141
C	AHOADA/ OKOGBE	20.95	0.025	0.120	0.159
D	BIG ELELE/UMUDIOGA	16.93	0.020	0.095	0.122
E	ELELE ALIMINI	18.65	0.023	0.107	0.146
F	MBIAMA/ ENGENNI COMMUNITY	15.44	0.019	0.089	0.121
	Mean Value	**18.83**	**0.023**	**0.107**	**0.142**

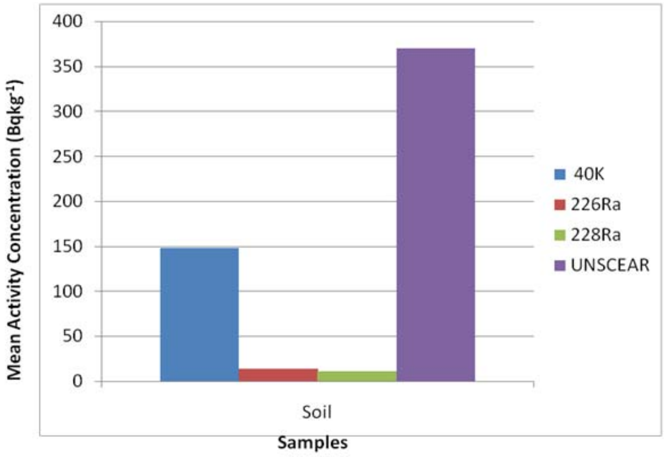

Figure 2: Radioactivity Concentration in Surveyed Soil samples and comparison with UNSCEAR standard (370 $Bqkg^{-1}$)

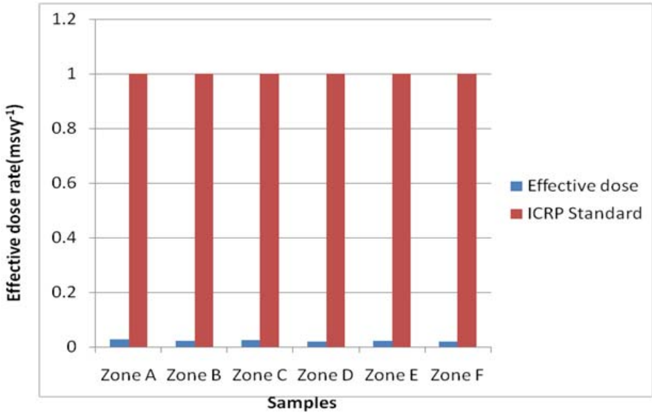

Figure 3: Effective dose (H_E) calculated for soil samples for all zones comparison with ICRP standard ($ImSvy^{-1}$)

5. Results and Discussions

The distribution of the radionuclide activity concentration contents in Soil samples analyzed is presented in Table 2. The specific activity values obtained varied from 98.84± 18.95 to 205. 98± 29.06 Bqkg-1 (average 148.10± 30.36 Bqkg-1) for 40K. 9.97± 3.77 Bqkg-1 to 15.41± 6.02 Bqkg-1 (average 13.28± 4.67 Bqkg-1) for 228Ra and 8.75± 2.65 Bqkg-1 to 14.05± 5.12 Bqkg-1 (average 11.11± 4.13 Bqkg-1) for 228Ra. (Table 2).The largest contributor to the activity concentration of radionuclide was 40K. The results for 40K lie within the range obtained elsewhere for surface soil primarily characterized as sand, gravy loams and sandy loams as well as some phosphate deposits (Ashraf et al., 2001, Obisesan, 2004). In fact, 40K being a naturally occurring radionuclide is present abundantly in the earth crust and in human body, hence it is expected to contribute significantly to man's committed effective dose through ingestion (Tchokossa et al., 1999). The activity concentrations of 226Ra, and 228Ra are relatively low compared to that of 40K, this might be due to the fact that being gases they are not only mobile (NCRP, 1987) but also they escape from the soil since it is an open system. The overall result shows that activity concentration of 226Ra, 228Ra and 40K in surveyed soil samples in the study area are within the world maximum acceptable limit of 35 Bqkg-1, 30 Bqkg-1 and 400 Bqkg-1 stipulated by UNSCEAR (2000). Also, the radium equivalent calculated is less than the maximum limit of 370 Bqkg-1 suggested by UNSCEAR (1993) for the safe use of building materials. For dose evaluation, the Effective dose ranged from 0.019mSvy-1 to 0.027mSvy-1 (mean 0.023mSvy-1). The highest value of 0.027mSvy-1 was recorded in Zone A and the lowest value of 0.019mSvy-1 was recorded in Zone F. this highest value recorded in Zone A compared with Zone F may be probably due to Oil exploitation and exploration activities which is more in Zone A, however no radiological damage is envisaged at this level. The external and internal hazard indices calculated ranges from 0.089 to 0.125 (mean 0.107) and 0.121 to 0.165 (mean 0.142). These values are less than unity, showing that the use of such soil may not have immediate radiological problems. However, the overall results are below the International Commission on Radiological Protection (ICRP, 1991) maximum permissible dose limit of 1.0mSvy-1 and may not pose any immediate danger to the public. The hazard indices calculated were all less than unity (1) showing that the use of soil from the area for building and agricultural purposes is still safe since their radiological impact is minimal (all these radiation hazard indices are within the acceptable limit), therefore, no immediate health risk as a result of these values obtained but continuous exposure may result to significant health impact Table 3 Figure 3.

6. Conclusion and Recommendation

Specific Activity Concentrations of radionuclide present in soil samples obtained from OML 58 and 61, Oil and Gas Producing Areas in the Niger Delta Region of Nigeria were identified and quantified using NAI (TI) detector. Their equivalent doses were also determined to assess the health implication on humans. The results of the study indicated that the radionuclide identified belong to the Naturally Occurring decay series headed by 226Ra (238U) and 232Th (228Ra) as well as the single decay type, 40K. The result also revealed that 40K made the largest contribution to the radionuclide contents and Specific Activity of 226Ra was found higher when compared with 228Ra, probably due to its mobility and that no 137-caesium was detected. Comparatively, high values of 40K in all samples may be partly due to the presence of feldspar and clay that characterizes the formations in the Niger Delta Region of Nigeria and also potassium is macronutrient and it is expected that the soil characteristics favor its mobilization. The study area is also noted for use of potassium based artificial fertilizers to improve food crops yield. In all, the Mean Specific Activity concentrations for 40K, 226Ra and 228Ra obtained in this study were low when compared with UNSCEAR standard of 370Bqkg-1, the Effective dose obtained were far below the limit of public exposure of 1mSvy-1 (ICRP, 1991). This may not pose any immediate danger to the public. It is thereby recommended that seasonal variations in radionuclide transfer should be investigated and regular monitoring of the areas should be conducted from time to time in other to take care of any eventuality resulting from long time consumption of food crops/stuffs produced from the soil in the study area and the suitability of the soil for construction and other purposes.

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