Natural Radioactivity and Associated Radiation Hazards in some Commonly Consumed Tubers and Cereals in Oil Mining Lease (OML) 58 and 61, Oil and Gas Producing Areas, Niger Delta Region of Nigeria

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Abstract: ***A survey of radioactivity concentration in some commonly consumed Tubers and Cereals within Oil Mining Lease (OML) 58 and 61, Oil and Gas Producing Areas in the Niger Delta Region of Nigeria was carried out. The study Area was divided into six zones A, B, C, D, E, F where Nine (9) Tuber samples and three (3) Cereals were harvested and collected from agricultural farms where they were produced. Food crop/stuff samples were dried at room temperature to a constant weight, powdered and sieved to pass through a 2mm-Mesh. All samples were then sealed in pre-treated 1-L Marinelli beakers for at Least 28 days for secular equilibrium to set-in before Gamma Spectroscopy analysis. The Canberra Passive Gamma Spectrometer with a well calibrated high purity germanium detector (HpGe) system was employed (NaI(T1)Detector, Model Bircom, Preamplifier Model 2001,Amplifier Model 2020,ADC Model 8075,HVPS Model 3105).Mean Specific Activity values obtained for 40K, 226Ra, 228Ra in Cereals are 39.25± 8.37 Bqkg-1, 11.39± 3.45 Bqkg-1 and 7.87± 2.72 Bqkg-1 and for Tubers, the mean Specific Activity values for 40K, 226Ra, 228Ra are 229.35± 27.19 Bqkg-1, 15.75± 4.53 Bqkg-1, and 10.90± 3.72 Bqkg-1 respectively. The Mean Radium equivalent Activity (Raeq) calculated for surveyed Cereals and Tubers are 25.67 Bqkg-1 and 48.62 Bqkg-1. The Mean effective Dose calculated for all surveyed samples ranged from 0.025mSvy-1 to 0.034 mSvy-1 which is far less than the ICRP standard which did not show any significant health impact. The radiation hazard indices (External hazard Index, (Hex), Internal hazard Index (Hin)} calculated in all surveyed samples were less than unity, therefore all food crops/stuffs examined are suitable for consumption. The results obtained are in agreement with other past works in Nigeria and other parts of the world (Mlwilo et al., 2007, Jibiri et al., 2007, Olowo, 1990, Arogunjo et al, 2005, G.Shanthi et al; 2009, Badar, et al., 2003, Baeza, et al., 2001 and others). There are presences of series radionuclide (238U and 232Th) and non-series (40K) in the samples surveyed, but their activity levels were low compared with UNSCEAR Standard and hence were not expected to constitute any health hazard to the inhabitants. However, no 137-caesium was detected. It is recommended that seasonal variations in radionuclide transfer should be investigated and regular monitoring of the areas should be conducted from time to time to check any eventuality as a result of long time consumption of the foodstuffs.***

Keywords: Radioactivity, Specific Activity, External Hazard Index (Hex) Internal hazard Index (Hin)

1. Introduction

Knowledge of natural radioactivity in man and his environment is important since naturally occurring radionuclides are the major sources of radiation exposure to man (UNSCEAR, 2000). Radioactive nuclides present in the natural environment enter the human body mainly through food and water. Besides, measurement of naturally occurring radionulides in the environment can be used not only as a reference when routine releases from nuclear installation or accidental radiation exposures are assessed, but also a baseline to evaluate the impact caused by non-nuclear activities (M.Asefi et al., 2005), The Niger Delta Region of Nigeria with its fragile ecosystem is the oil producing region of the country and it is also a region of intensive shipping-incidentally, it is a food basket, mainly water-food source and sanctuary for one of the world's greatest biodiversity. Yet, wastes from several oil-related activities: exploration, drilling, production, processing and crude transportation are continuously released into the intricate creeks and creek lets systems of the Niger Delta. Apart from the man-made sources, the radiation burden of the environment is constantly being enhanced by ionizing radiations from natural sources and their transfers to plant produce have been noted by some authors (Velasco et al., 2004). Radionuclide have always been present in food at various levels depending on factors such as radioactivity contents in soil and the transfer characteristics from the environment medium to food stuff and hence to man (Amaral et al., 1998, IAEA., 1989, Thiry et al., 2002; Travnkova et al., 2002; Albrecht et al., 2002). The aquatic environment like Niger Delta received the greatest input of radionuclide from atmospheric testing of nuclear weapon and low levels of radioactive wastes discharge from nuclear industries where they exist. Sea also contains naturally occurring radionuclide of primordial and cosmogenic origin. Both aquatic plants and animals accumulate elements to concentrations greater than those of the ambient water (Akinloye et al., 1999). As a source of food, the aquatic environment provides a large fraction of the diet through aquatic foods of some individual and certain local population. Contamination of fish therefore, constitute a significant pathway for uptake of radiocaesium to man. The presence of 226Ra in water constitutes significantly to the radiation intake in the general populace (Olomo, 1990). Tubers and cereals are important component of the total diet and the presence of natural radionuclide 40K, 238U and 232Th in them have certain radiological implication not only in the foods, but also on the populace consuming these food sources (Fortunate et al., 2004). Tubers and cereals contamination can result from various processes: direct deposition to surfaces absorption by their skin and transport to the interior deposition to the above –ground of the plant, absorption to interior and it's subsequently parts transfer to the plant etc. (Carim F., 2010). This work therefore measured the activity of radionuclides in the food chain through the examination of tubers and cereals in OML 58 and 61 Area, Oil and Gas Producing Areas in the Niger Delta Region of Nigeria.

2. Study Area

The area is situated approximately between latitudes 5013c– 15c N and longitude 60 36c -40c E of the North Western quadrant of Rivers State of Nigeria (UNDP, 2006).The area which is made up of Ogba/Egbema/Ndoni, Ahoada-West, Ahoada-East, Emuoha, Ikwere local governments of Rivers State and are within Oil Mining Lease (OML) 58 operated by Total Fina E/F and Oil Mining Licence (OML 61) operated by the Nigerian Agip Oil Company (NAOC),both multi-national oil companies in Nigeria respectively. The area is the heart of the hydrocarbon industry and contributes the highest chunk feeder of the natural gas to the Nigeria Liquefied Natural Gas Project (Figure 1).

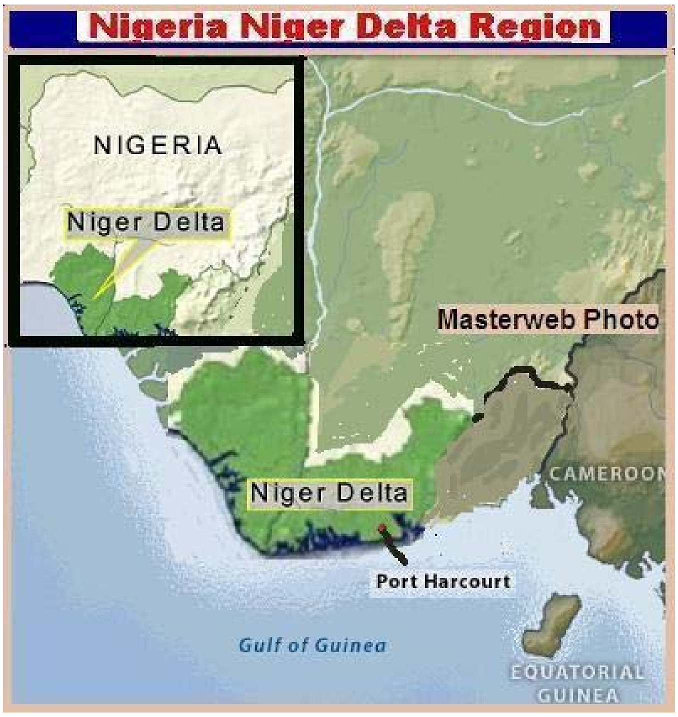

Figure 1: Photo Map of the Niger Delta Region of Nigeria

3. Materials and Methods

The surveyed area was divided into six zones: A,B,C,D,E,F and a total of twelve (12) samples of nine(9) Tubers and three (3) Cereals were harvested from agricultural farms (Table 1(a&b)). Factors such as population. density, farm settlements, educational institutions, markets, cultural background and consumption rates were considered. Yams, Cassava, and Cocoyam were processed into food composites such as garri, cassava floor, while yam was processed into yam floor and pounded yam. Pounded yam was sun-dried at a temperature of about 250C to a constant weight. For cereals, maize or corn was dried at room temperature until a constant weight. They were later grounded and homogenized. These processed food samples were crushed, sieved with 2-mm sieve and weighted. They were later placed in 1-L Marinelli beaker which was previously washed through with dilute HNO3 and rinsed with distilled water. Each marinelli beaker was sealed for at least 28 days to allow for build-up of radon and radon daughters (secular equilibrium) in the decay series headed by 226Ra and 228Ra before their Spectrometry measurements commenced. The Gamma-counting equipment was a Canberra vertical High purity coaxial Germanium (HpGe) crystal detector (NaI(T1)Detector,Model Bircom,Preamplifier Model 2001,Amplifier Model 2020,ADC Model 8075,HVPS Model 3105).enclosed in a 100mm lead shield and coupled to a Canberra Multichannel Analyzer (MCA) computer system (P. Tchokossa et al., 2011). The quantification of radionuclides present in samples were obtained through accurate energy and efficiency calibration using a well calibrated standard sources supplied by the International Atomic Energy Agency (IAEA), Vienna to Centre for Energy Research and Development (CERD), Obafemi Awolowo University, Ile-Ife where these samples were analyzed. The techniques used are well described elsewhere (IAEA.,1984, P.Tchokossa et al., 2011).The MCA was calibrated so as to display gamma photo peaks in the energy range of 200-3000KeV, this being the energy range for radionuclides of interest identified with reliable regularity. The counting time was 36000 s (P. Tchokossa et al., 2011). The photo peaks observed with reliable regularity belong to the naturally occurring series – decay radionuclides led by 238U and 232Th, as well as the non-series decay type 40K.. The activities of radionuclide were calculated from the difference between net peak and net peak background areas, accumulation time, absolute peak efficiency, absolute y-ray emission probability and the sample volume (P. Tchokossa et al., 2011).

4. Data Presentation

Table 1a: 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 1b: Geographical locations of Surveyed Tubers and Cereals

S/N	*Sample Name*	*Sample Type TUBERS*	*Geographical Location(s)*			
			Zone/Code	*Latitude ø*	*Longitude(λ)*	*Botanical Name*
1	Cassava	Tubers	CaA	05 20.701	06 39.388	Manilot Spp
2	Cassava	Tubers	CaD	05 05.588	06 47.752	Manilot Spp
3	Cassava	Tubers	CaE	05 03.434	06 44.044	Manilot Spp
4	Yam	Tubers	YaA	05 20.608	06 39.358	Discorea Spp
5	Yam	Tubers	YaD	05 05.751	06 48.336	Discorea Spp
6	Yam	Tubers	YaB	05 23.610	06 40.210	Doscorea Spp
7	Cocoyam	Tubers	CoC	05 20.591	06 39.387	Colocasia Esailuta
8	Cocoyam	Tubers	CoD	05 06.230	06 48.703	Colocasia esailuta
9	Cocoyam	Tubers	CoF	05 03.850	06 20.928	Colocasia esailuta
CEREALS						
10	Maize/corn	Cereals	MaA	05 20.591	06 39.387	Zea mays
11	Maize/corn	Cereals	MaC	05 04.563	06 39.257	Zea mays
12	Maize/corn	cereals	MaF	05 03.850	06 26.928	Zea mays

Table 2: Mean Specific Gamma Activity Concentration and Radium equivalent activity (Raeq) for all surveyed samples in zones A to F, OML 58 and 61 Niger Delta Region of Nigeria

		Mean Activity Concentration						*Radium equivalent (Raeq),(Rqkg-1)*	
		Tubers			*Cereals*				
		40K	*226Ra*	*228Ra*	*40K*	*226Ra*	*228Ra*	*Tubers*	*Cereals*
A	OMOKU/ OBITE/ AKABUKA	204.41±24.69	12.48±3.34	11.73±5.07	30.25±9.22	8.98±3.31	7.62±2.11	44.99	22.15
B	OBRIKOM/ EBOCHA/ MGBEDE	189.26±17.94	19.21±6.22	12.08±4.29	40.63±12.26	9.46±3.62	6.43±1.98	51.06	25.67
C	AHOADA/ OKOGBE	280.84±33.09	18.03±5.29	13.21±3.96	39.83±13.27	11.72±2.93	6.79±2.43	58.54	24.50
D	BIG ELELE/ UMUDIOGA	213.82±29.77	16.75±4.37	10.94±2.21	36.44±10.11	10.89±3.02	8.11±3.11	44.84	21.68
E	ELELE ALIMINI	310.83±31.27	12.13±4.12	7.52±2.78	40.68±9.58	13.82±4.44	6.67±1.99	48.65	29.66
F	MBIAMA/ ENGENNI COMMUNITY	176.95±26.38	15.87±3.83	9.89±4.02	47.67±2.62	13.53±4.10	9.20±3.62	43.64	30.36
	Mean Value	229.35±27.19	15.75±4.53	10.90±3.72	39.25±8.37	11.39±3.45	7.87±2.72	48.62	25.67

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

	Tubers	*Absorbed Dose*			*Hazard Indices*
Area Code	*Surveyed Area*	*D(nGy-1)*	*Effective Dose (Msvy-1)*	*Hex*	*Hin*
A	OMOKU/ OBITE/ AKABUKA	21.74	0.026	0.122	0.155
B	OBRIKOM/EBOCHA/ MGBEDE	24.22	0.029	0.138	0.190
C	AHOADA/ OKOGBE	28.31	0.034	0.158	0.207
D	BIG ELELE/UMUDIOGA	21.48	0.025	0.112	0.155
E	ELELE ALIMINI	23.25	0.028	0.126	0.159
F	MBIAMA/ ENGENNI COMMUNITY	20.81	0.025	0.118	0.161
	Mean Value	23.30	0.028	0.129	0.171

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

	Fruits	*Absorbed Dose*			*Hazard Indices*
Area Code	*Surveyed Area*	*D(nGy-1)*	*Effective Dose (Msvy-1)*	*Hex*	*Hin*
A	OMOKU/ OBITE/ AKABUKA	10.16	0.012	0.060	0.084
C	AHOADA/ OKOGBE	11.21	0.014	0.060	0.098
F	MBIAMA/ ENGENNI COMMUNITY	13.92	0.017	0.082	0.119
	Mean Value	11.76	0.014	0.069	0.100

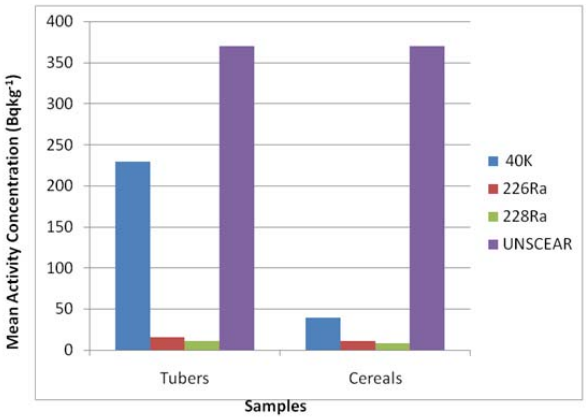

Figure 2: Bar chart showing Radioactivity Concentration in surveyed Tubers and Cereals Samples and Comparison with UNSCEAR Standard (370 Bqkg-1)

5. Results and Discussion

Radioactivity Concentration in Tubers

The Specific Activity for 40K ranged from 176.95± 26.38 Bqkg-1 in zone F to 310.83± 31.27 Bqkg-1 in zone E (Mean : 229.35± 27.19 Bqkg-1), 226Ra ranged from 12.13± 4.12 Bqkg-1 in zone E to 19.21± 6.22 Bqkg-1 in zone B (Mean: 15.75± 4.53 Bqkg-1). 228Ra ranged from 7.52± 2.78 Bqkg-1 in zone E to 13.21 ± 3.96 Bqkg-1 in zone C (Mean: 10.90± 3.72 Bqkg-1). The Radium equivalent Activity, (Raeq) calculated ranged from 43.64 Bqkg-1 in zone F to 58.54 Bqkg-1 in zone C (Mean: 48.62 Bqkg-1). Table 2. The Absorbed Dose ranged from 20.81nGyh-1 in Zone F to 28.31nGyh-1 in Zone C (Mean: 23.30nGyh-1). The Effective Dose (HE) calculated ranged

from 0.028mSvy-1 in Zone F to 0.034mSvy-1 in Zone C (Mean: 0.028mSvy-1). The External hazard index (Hex) ranged from 0.112 from Zone D to 0.158 in Zone C (Mean: 0.129),the Internal hazard Index (Hin) ranged from 0.155 in Zones A and D to 0.207 in Zone C (Mean: 0.171). The overall activity concentration was obtained from 40K with the highest value recorded in cassava (Manilot spp) in Zone E. This might be due to the high water content of Tubers which tend to accumulate soluble radionuclide. The highest activity concentration recorded in cassava may be due to the direct contact it has with the soil unlike cocoyam (colocasia esailinta) which extract its nutrients including radionuclide not directly from the soil but instead, through a principal root of the plant. The activity concentration of 226Ra and 228Ra are relatively of the same order of magnitude and for dose evaluation; the highest value was recorded in zone C which did not indicate any negative health impact as the values were far below the ICRP standard.

Radioactivity Concentration in Cereals

The Specific Activity obtained for 40K ranged from 30.25± 9.22 Bqkg-1 in Zone A to 47.67± 2.62 Bqkg-1 in Zone F, (Mean: 39.25± 8.37 Bqkg-1), 226Ra ranged from 8.98± 3.31 Bqkg-1 in Zone A to 13.53 ± 4.10 Bqkg-1 in Zone F (Mean: 11.39± 3.45 Bqkg-1), 228Ra ranged 6.79± 2.43 Bqkg-1 in Zone C to 9.20± 3.62 Bqkg-1 in Zone F (Mean: 7.87± 2.72 Bqkg-1).The Radium equivalent activity ranges from 22.15 Bqkg-1 in zone A to 30.36

Bqkg-1 in Zone F (Mean: 25.67 Bqkg-1) The Absorbed Dose ranged from 10.16nGyh-1 in Zone A to 13.92nGyh-1 Zone F (mean: 11.76nGyh-1).The Effective Dose calculated ranged from 0.012mSvy-1 in Zone A to 0.017mSvy-1 in Zone F (Mean: 0.014mSvy-1). The External Hazard Index (Hex) ranged from 0.060 in Zones A and B to 0.082 in Zone F (Mean: 0.069) while the Internal hazard Index (Hin) ranged from 0.084 in Zone A to 0.119 in F (Mean: 0.100). From these results, the overall highest activity concentration was from 40K in Zone C with 39.83± 13.27 Bqkg-1 while the lowest was from 228Ra with 6.79± 2.43 in Zone C. The same order of magnitude of the value obtained from 226Ra and 228Ra was in line with similar study by Arogunjo et al., (2005). All the activity concentration values obtained are far less than the UNSCEAR standard, the calculated radiation indices are all less than unity, and the evaluated dose was by far less than the ICRP standard of 1mSvy-1. With these results, no radiological damage is envisaged and all the examined food crops/ stuff are safe for consumption but regular monitoring is hereby suggested as a result of long term continuous consumptions of these food crops / stuffs. Table 3(a) and 3(b), Figure 2, Figure 3.

6. Conclusion and Recommendations

Specific Activity Concentrations of radionuclide present in tubers and cereals 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., however,137-caesium was not detected. 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. 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 these food crops / stuffs.

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