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Research Paper

Assessment of Natural Radionuclide Content in Some Commonly Consumed Vegetables and Fruits in Oil Mining Lease (OML) 58 and 61, Oil and Gas Producing Areas in the Niger Delta Region of Nigeria Using Gamma-Ray

Physics

KEYWORDS : Naturally Occurring Radioactive Materials (NORM), Potassium-40(40K), Urannium-238(226Ra), Thorium-232(228Ra)

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ABSTRACT

The presence and levels of Naturally Occurring Radionuclides (NORM) in some commonly consumed vegetables and fruits in OML 58 and 61, in Niger Delta Region of Nigeria were determined in this work and the effect of resulting dose on the population assessed. Twenty (20) Vegetable samples and eleven (11) of fruits were harvested and collected from agricultural farms and gardens where they were produced. Six Zones (A, B, C, D ,E ,F) were selected considering factors such as population density, educational Institutions, farm settlements, markets and cultural background taken into account the consumption rates. Food crops samples were dried at room temperature to a constant weight powdered and sieved to pass through a 2mm mesh. All the 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, 228Ra in Vegetables are 95.95± 18.85 Bqkg-1, 10.79 ± 3.46 Bqkg-1, 6.83 ± 2.32 Bqkg-1and in fruits, the Mean Specific Activity values for 40K, 226Ra, 228Ra, are 77.67 ± 18.90 Bqkg-1, 8.12 ± 3.00 Bqkg-1, 6.17 ± 2.15 Bkg-1.The Mean Radium Equivalent Activity (Raeq) calculated for vegetables and fruits ranged from 27.81 Bqkg-1 to 18.60 Bqkg-1. The Mean Effective dose calculated in all surveyed samples ranged from 0.014 mSvy-1 to 0.030mSvy-1 respectively which did not show any significant health impact. The radiation hazards indices (External hazard Index (Hex), Internal hazard Index (Hin) calculated in all the surveyed samples were less than unity (ICRP) standard, therefore all food crops examined are suitable for consumption. The overall results obtained agreed with other earlier works in Nigeria and all over the world(Arogunjo et al; 2005, Olomo; 1990, G. Shanthi et al; 2009., Mlwilo et al; 2007; Jibiri et al; 2007; Badar,et al.,2003,Baeza et al.,2001 etc). In conclusion, the study confirmed the presence of series radionuclides (238U, 232Th) and non-series, 40K. in the areas surveyed but their activity levels were low when compared with the UNSCEAR standard and hence were not expected to constitute any health hazard to the inhabitants. However,it is recommended that seasonal variations in radionuclides 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 continuous consumption of these foodcrops.

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 transfer 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 acquatic 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 acquatic 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). Vegetables and fruits 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). Vegetables and fruits 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 vegetables and fruits in OML 58 and 61 Area,Oil and Gas Producing Areas in the Niger Delta Region of Nigeria.

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 Funa 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.

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MATERIALS AND METHODS

The study area was divided into six zones (A,B,C,D,E,F) and a total of thirty one (31) samples of Twenty (20) vegetables and eleven (11) fruits were harvested and collected from agricultural farms and gardens where they were produced and uniformly spread within the zones (Table 1a and b).Factors such as population density, farm settlements, educational institutions, markets, cultural background and consumption rates were considered. Several kilograms of each type of vegetable surveyed (Pumpkin seed and leaf, Okro, waterleaf) were collected. The vegetation was held in the hand while being cut to a height of 0.05m above the ground level, in order to stimulate the height at which grazing takes place. Care was taken during mixing to avoid contamination with other sample. They were dried to a constant weight and reduced to powder form by crushing. For the fruits surveyed, (Orange and Plantain), were harvested from farms. They were peeled and together with the peels, they were ground before being sealed. All samples were further dried at room temperature at constant weight, powdered and sieved to pass through a 2mm mesh and sealed in pre-treated 1-L Marinelli beakers for at least 28 days for secular equilibrium to set-in before gamma spectroscopy analysis. The gamma- counting equipment was a Canberra vertical High purity coaxial germanium (HpGe) Crystal detector, enclosed in a 100 – mm lead shield and coupled to a Canberra Multichannel Analyzer (MCA) computer system. model (NaI(T1)Detector,Model-Bircom,Preamplifier Model 2001,Amplifier Model 2020,ADC Model 8075,HVPS Model 3105)(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).

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 Vegetables and Fruits

S/N	Sample Name	Sample Type VEGETABLE	Code	Geographical Location(s)		
				Latitude ø	Longitude(λ)	Botanical Name
1	Pumpkin Seed	Vegetable	Pus A	05 20.607	06 39.362	Corchonis Olitorius
2	Pumpkin Seed	Vegetable	Pus D	05 06.231	06 48.706	Corchonis Olitorius
3	Pumpkin Seed	Vegetable	Pus C	05 20.591	06 39.387	Corchonis Olitorius
4	Pumpkin Leaf	Vegetable	Pus A	05 20.685	06 40.165	Corchonis Olitorius
5	Pumpkin Leaf	Vegetable	Pus B	05 23.616	06 40.187	Corchonis Olitorius
6	Pumpkin Leaf	Vegetable	Pus C	05 04.563	06 39.257	Corchonis Olitorius
7	Pumpkin Leaf	Vegetable	Pus D	05 06.247	06 48.723	Corchonis Olitorius
8	Pumpkin Leaf	Vegetable	Pus E	05 03.425	06 44.004	Corchonis Olitorius
9	Pumpkin Leaf	Vegetable	Pus F	05 03.861	06 26.917	Corchonis Olitorius
10	Okoro	Vegetable	OkB	05 28.448	06 42.996	Abelmostous
11	Okoro	Vegetable	OKD	05 06.245	06 48.718	Esculentus
12	Okoro	Vegetable	OKE	05 03.425	06 44.004	Esculentus
13	Okoro	Vegetable	OKF	05 03.861	06 26.917	Esculentus
14	Okoro	Vegetable	OKc	05 04.563	0639.257	sculeEntus
15	Waterleaf	Vegetable	WB	05 23.622	06 40.194	Talinum tangulare
16	Waterleaf	Vegetable	WC	05 04.563	06 39.257	Talinum tangulare
17	Waterleaf	Vegetable	WD	05 06.230	06 48.702	Talinum tangulare
18	Waterleaf	Vegetable	WE	05 03.425	06 44.004	Talinum tangulare
19	Waterleaf	Vegetable	WF	05 03.861	06 26.917	Talinum tangulare
20	Waterleaf	Vegetable	WA	05 20.685	06 40.165	Talinum tangulare
FRUITS						
21	Plantain	Fruits	PIA	05 20.607	06 39.361	Musa paradisiaca
22	Plantain	Fruits	PIB	05 23.622	06 40.194	Musa paradisiacal
23	Plantain	Fruits	PIC	05 04.563	06 39.257	Musa paradisiacal
24	orange	fruits	PID	05 06.256	06 48.736	Citrus Spp
25	Orange	Fruits	PIE	05 03.425	06 44.004	Citrus Spp
26	Orange	Fruits	PIF	05 03.850	06 20.928	Citrus Spp
27	Orange	Fruits	OrA	05 20.610	06 39.350	Citrus Spp
28	Orange	Fruits	OrC	05 04.563	06 39.257	Citrus Spp
29	Orange	Fruits	OrE	05 03.425	06 44.004	Citrus Spp
30	Orange	Fruits	OrF	05 03.850	06 20.928	Citrus Spp
31	orange	fruits	OrB	05 28.454	06 42.982	Citrus Spp

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

Area Code/ Surveyed		Mean Activity Concentration (Bqkg-1)						Radium equivalent (Raeq),(Bqkg-1)	
	Vegetables			Fruits			Vegetables 228Ra	Fruits	
		40K	226Ra	228Ra	40K	226Ra			
A	OMOKU/ OBITE/ AKABUKA	78.85± 21.42	13.83±4.53	8.26±2.44	60.36±12.99	7.41±2.18	5.51±1.97	31.72	19.94
B	OBRIKOM/ EBOCHA/ MGBEDE	89.44±19.41	8.64±2.72	5.40±1.88	73.69±19.39	6.95±2.52	5.42±2.04	23.25	20.56
C	AHOADA/ OKOGBE	136.73± 26.68	10.75±4.02	7.63±2.34	81.29±19.39	9.87±3.09	6.97±2.51	31.40	26.10
D	BIG ELELE/ UMUDIOGA	91.51±20.06	9.70±2.97	5.52±2.20	72.10±24.28	9.84±3.87	7.66±2.45	24.64	10.96
E	ELELE ALIMINI	101.42±28.15	7.23±2.03	6.48±2.07	70.28±21.08	9.25±3.43	6.11±1.69	24.31	18.27
F	MBIAMA/ ENGENNI COMMUNITY	77.76±24.08	14.60±4.49	7.67±2.98	71.67±16.24	7.40±2.91	5.34±2.25	31.56	15.79
	MEAN VALUE	95.95±18.85	10.79±3.46	6.83±2.32	77.67±18.90	8.12±3.00	6.17±2.15	27.81	18.60

Table 3(a): Mean calculated Radiation Hazard Indices of all surveyed vegetables samples for all zones in OML 58 and 61, Niger Delta Region of Nigeria.

	Vegetables				Hazard Indices
Area Code	Surveyed Area	D(nGy-1) Absorbed Dose	Effective Dose (msvy-1)	Hex	Hin
A	OMOKU/OBITE/AKABUKA	14.73	0.018	0.086	0.123
B	OBRIKOM/EBOCHA/ MGBEDE	11.05	0.030	0.063	0.086
C	AHOADA/OKOGBE	13.99	0.023	0.063	0.083
D	BIG ELELE/UMUDIOGA	11.43	0.014	0.089	0.086
E	ELELE ALIMINI	11.67	0.014	0.059	0.086
F	MBIAMA/ ENGENNI COMMUNITY	15.52	0.018	0.086	0.125
	MEAN VALUE	13.07	0.020	0.074	0.098

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

	Fruits			External hazard Index	Internal hazard Index
Area Code	Surveyed Area	Absorbed Dose D(nGy-1)	Effective Dose (msvy-1)	Hex	Hin
A	OMOKU/OBITE/AKABUKA	8.19	0.010	0.054	0.074
B	OBRIKOM/EBOCHA/MGBEDE	9.46	0.012	0.055	0.074
C	AHOADA/OKOGBE	12.31	0.015	0.071	0.081
D	BIG ELELE/UMUDIOGA	12.34	0.015	0.071	0.098
E	ELELE ALIMINI	11.83	0.020	0.059	0.084
F	MBIAMA/ENGENNI COMMUNITY	8.19	0.025	0.056	0.076
	Mean Value	10.39	0.016	0.061	0.081

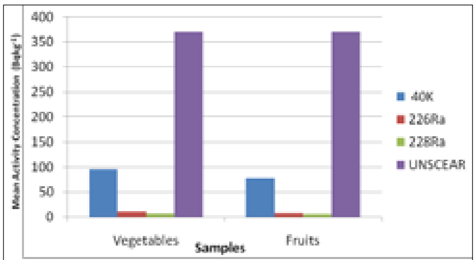

Figure 2: Bar chart showing Radioactivity Concentration in surveyed Soil Samples and Comparison with UNSCEAR Standard (370 Bqkg-1)

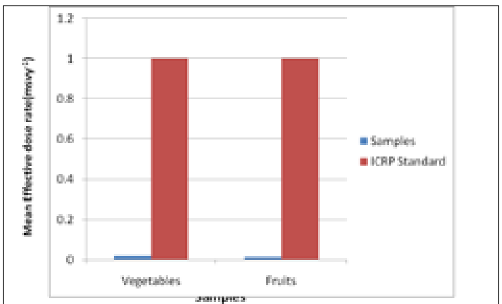

Figure 3: Bar chart showing Mean Effective Dose (H_E) Calculated for Vegetables and Fruits Samples and Comparison with (ICRP Standard 1mSvy-1)

RESULTS AND DISCUSSION

(a) Radioactivity Content in Vegetables.

The Specific Activity for 40K ranged from 77.76 ± 24.08 Bqkg-1 in zone F to 136. 73 ± 26.68 Bqkg-1 in zone C (Mean 95.95 ± 18.85 Bqkg-1). 226Ra ranged from 7.23 ± 2.03 Bqkg-1 in zone E to 14.60 ± 4.49 Bqkg-1 in zone F (Mean: 10.79 ± 3.46 Bqkg-1). 228Ra ranged from 5.40 ± 1.88 Bqkg-1 in zone B to 8.26 ±2.44 Bqkg-1 in zone A (Mean: 6.83 ± 2.32 Bqkg-1). The Radium Equivalent Activity (Raeq) calculated ranged from 23.25 Bqkg-1 in zone B to 31.72 Bqkg-1 in zone A (Mean: 27.81 Bqkg-1) (Table 2).The absorbed Dose ranged from 11.05nGyh-1 zone B to 15.52nGyh-1 (mean: 13.07nGyh-1). The Mean Effective dose calculated ranged from 0.014 mSvy-1 in zone B to 0.030 mSvy-1 in zone B (Mean: 0.020 mSvy-1). The External Hazard Index (Hex) ranged from 0.059 in zone E to 0.086 in zones A and F (Mean: 0.074). The Internal Hazard Index (Hin) ranged from 0.083 in zone C to 0.125 in zone F (Mean: 0.098). In all, the highest activity concentration came mainly from 40K with the highest value obtained from water leaf (Talinum tangulare) in zone C and the lowest obtained from pumpkin leaf (corchoris olitorius) in zone F. The Specific Activity for 226Ra were relatively higher compared to that of 228Ra with highest obtained in water leaf (Talinum tangulare) in zone F and the lowest obtained also in water leaf in zone F and the lowest obtained in Okro(abelmostous esculentus) in zone E while for 228Ra the highest was obtained in pumpkin seed (corchoris olitorius) in zone C and the lowest obtained in water leaf also in zone C (Figure 2) The major bedrocks in the study area are well

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known to accumulate Naturally Occurring Radioactive Material (NORM) (Lambert et al., 1992; Baeza et al., 2001). Leaf vegetables seem to absorb more potassium than other crops. Also, potassium is macronutrient, so the concentration may be high and it may be expected that the soil characteristics favour the mobilization of potassium and its subsequent migration into the plant. Also the use of artificial fertilizers to improve crop yields is common in the zones where this elevation was recorded. The levels therefore detected are within the range reported in different parts of the world (Badran et al ., 2003; Baeza et al; 2001); For Dose evaluation, the highest dose rate was recorded in zone B and lowest in both zones D and F. They were far lower than the ICRP standard (Figure 3) this did not show any significant health impact. The radiation hazard indices (Hex, Hin) calculated were less than Unity, therefore all vegetables samples examined are suitable for consumption. The overall results obtained agreed with other works in Nigeria and parts of the world (Arogunjo et al., 2005; Jibiri et al; 2007, Olomo, 1990; G. Shanthi et al., 2009; Mlwilo et al., 2007).

(b) Radioactivity Content in Fruits

In surveyed fruits samples, 40K ranged from 60.36± 12.99 Bqkg-1 in zone A to 81.29 ± 19.3 Bqkg-1 in Zone C (Mean: 77.67 ± 18.90 Bqkg-1), 226Ra ranged from 6.95 ± 2.52 Bqkg-1 in zone B to 9.87± 3.09 Bqkg-1 in zone C (Mean: 8.12 ± 3.00 Bqkg-1) 228Ra ranged from 7.52 ± 2.78 Bqkg-1 in zone E to 13.21 ± 3.96 Bqkg-1 in zones C (Mean: 10.90 ± 3.72 Bqkg-1. The Radium equivalent Activity (Raeq) calculated ranged from 10.96 Bqkg-1 in zone D to 26.10 Bqkg-1 in zone C (Mean: 18.60 Bqkg-1). The Absorbed Dose ranged from 8.19nGyh-1 zone A to 12.34 nGyh-1 in zone D (Mean: 10. 39 nGyh-1). The Effective Dose calculated ranged from 0.010 mSvy-1 in zone A to 0.025 mSvy-1 in Zone F (Mean: 0.016 mSGyh-1). The External hazard index (Hin) ranged from 0.054 in zone A to 0.071 in zones C and D (Mean: 0.061), the Internal hazard Index (Hin) ranged from 0.081 in zone C to 0.098 in zone D (Mean: 0.081). The highest activity concentration was from 40K recorded in orange in zone C, 228Ra recorded higher activity concentration than 226Ra, this is because 226Ra is more mobile than 228Ra. For Dose evaluation, the highest was recorded in zone F and the lowest in zone A. However, the values obtained suggest that the dose from intake of these radionuclides by the food crops is low compared with ICRP standard and that harmful effects are not expected. Tables 3a and 3b.

CONCLUSION AND RECOMMENDATIONS

Specific Activity Concentrations of radionuclides present in vegetables and fruits 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 Nationally 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. 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 favour 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 foodcrops..

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