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Assessment of norm-containing food crops/stuffs in OML 58 & OML 61 within the Niger delta region of Nigeria

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Abstract

A preliminary assessment of the levels of natural radionuclide in some commonly consumed cereals, fruits, vegetables and tubers within OML 58 and OML 61 in Niger Delta Region of Nigeria has been carried out. The areas under study were divided into six (6) zones (A,B,C,D,E,F) and investigated. An *in-situ* measurement approach was adopted using Nuclear Radiation Meter (Radarlert-100), and a handheld Global Positioning System (GPS 76 CSX) equipment. Sixteen (16) readings each was taken in each of the six zoned areas making a total of ninety-six (96) food crops samples which was randomly selected. Measured average radiation levels in each of the six zones ranges between 0.009±0.001 mRhr^{-1} (0.479±0.038 mSvyr^{-1}) to 0.020± 0.001 mRhr^{-1} (1.064±0.065 mSvyr^{-1}) for zone A, 0.011±0.001 mRhr^{-1}, (0.585±0.041 mSvyr^{-1}) to 0.022±.002 mRh^{-1} (1.170±0.105 mSvyr^{-1}) for zone B, 0.010±0.001 mRhr^{-1} (0.532±0.048 mSvyr^{-1} to 0.025± 0.002 mRhr^{-1} (1.330±0.016 mSvyr^{-1}) for zone C, 0.010±0.001 mRhr^{-1} (0.532±0.048 mSvyr^{-1}) to 0.028±0.002 mRhr^{-1} (1.490±0.134 mSvyr^{-1}) for Zone D, 0.005±0.000 mRhr^{-1} (0.266±0.021 mSvyr-1) to 0.022±0.002 mRhr^{-1} (1.170±0.105 mSvyr^{-1}) for Zone E, 0.010±0.001 mRhr^{-1} (0.532 ± 0.048 mSvyr^{-1}) to 0.016±0.001 mRhr^{-1} (0.851±0.068 mSvyr^{1}) for Zone F. The mean food crop radiation levels ranges from 0.012±0.001 mRhr^{-1} (0.798±0.065 mSvyr^{-1}) to 0.016±0.001 mRhr^{-1} (0.849±0.067 mSvyr^{-1}) while the mean background radiation levels ranges from 0.011±0.001 mRhr^{-1} (0.585±0.041 mSvyr^{-1}) to 0.015±0.001 mRhr^{-1} (0.798±065 mSvyr^{-1}). The annual equivalent dose estimated were in the range of 0.613 mSvyr^{-1} to 0.849 mSvyr^{-1} far below the dose limits for radiological workers (20 mSvyr^{-1}) and the dose limit for the public (1 mSvyr^{-1}) (ICRP, 1994). Comparison of the measured radiation levels of the food crops samples with the normal background levels show that 45 samples which represent 46.8% of the whole sample exceeded the normal background level of 0.013 mRhr^{-1} (ICRP, 1994). These values obtained will not pose any immediate radiological health hazard to the populace consuming these food crops/stuffs but may have some long-term health side-effects.

Keywords: Radio-toxicity; Radiation; Radioactive materials; Radiological health hazard; Natural radionuclide.

Introduction

Radiation plays an important and sometimes vital role in our everyday lives. Every day each of us is exposed to naturally occurring quantities of radiation. We are exposed to this Naturally Occurring Radioactive Materials (NORM) through the air we breathe, the food we eat, the soil on which we walk, the water we drink, and even within our bodies (Ademola, 2008). Monitoring for radioactive materials are therefore of primary importance for human and environmental protection, but rapid and accurate method for the assay of radioactivity is essential (El-Bahi, 2004).

Over 60 radio-nuclides (radioactive elements) can be found in nature, and they are classified in three general categories- Primordial-formed before the creation of the earth, cosmogenic - formed as a result of cosmic ray interactions, Artificial radio-nuclides enhanced or formed due to human actions or activities (Eyebiokin *et al*., 2005). The series of naturally occurring radio-nuclides often found in the food chain are Uranium-238 and Thorium-232 and their progenies while the non-series one is the potassium-40(^{40}K). Potassium-40 is the principal naturally occurring source of internal radiation, despite its low isotopic abundance (ICRP, 1994). The deleterious radiological health hazards posed by human activities, especially in the production of energy, research, medical application of nuclear facilities and oil and gas extraction and production have attracted great concern and tremendous interest over the years in the field of radiation protection (Arogunjo *et al*., 2004). Dietary pathways become contaminated with radioactive materials from these man-made applications during routine operation, accidents and migration of radio-nuclides from radioactive waste disposal repositories into the biosphere. This anthropogenic contribution gained prominence after the Chernobyl nuclear power plant accident on 26th April 1986 when large quantities of the radioactive substances were released to the environment, which eventually found their way in the soil and vegetation (Tang, *et al*., 2003; Rahman and Voigt, 2004). One of the major anthropogenic sources of contamination in the environment is radiocaesium (137Cs, half-life 30.2 years), as reported by some authors (Rahman and Voight, 2004, Velasco *et al*., 2004; Arogunjo *et al*., 2005). It is a dominant fission product with high relative mobility in the soil-plant system, long-term bioavailability, and high radio-toxicity and is long lived. Apart from these man-made sources, the radiation burden of the environment is constantly being enhanced by ionizing radiations from natural sources and their transfer to plant and produce have been noted by some authors (Velasco *et al*., 2004; Badran *et al*., 2003).

Contamination of the food chain occur as a result of direct deposition of these radio-nuclides on plants leaves, fruits, tubers, root uptake from contaminated soil or water, and animals ingesting contaminated plants, soil or water. Considerable efforts are being made by many authors in many parts of the world to measure the activity of radio-nuclides in the food chain and the estimated soil-plant transfer of rado-nuclides (Velasco et al., 2004). Some works have been carried out in this area by some authors in recent time. The aquatic environment (like Niger Delta environment) received the greatest input of radio-nuclides from atmospheric testing of nuclear weapons and low levels of radioactive wastes discharges from nuclear industries where they exist. Sea also contains naturally occurring radio-nuclides 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, that 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 the uptake radio-caesium to man. The presence of 226Ra in water constitutes a major source of naturally occurring radionuclide and its content in food contributes significantly to the radiation intake on the general populace (Olomo, 1990). Fruits, Vegetables, Cereals, and Tubers are vital in our diet and presence of natural radio-nuclides ^{40}K, ^{238}U and ^{232}Th in them have certain radiological implication not only in the foods, but also on the populace consuming these food sources (Fortun, *et al*., 2004). These doses received by a person consuming aquatic foodstuffs, fruits, vegetable depend on the radio-nuclides concentration of the food and the quantity (Jibiri and Farai, 1998; Farai and Oni, 2002).

Study Area

The area is situated approximately between latitudes 5^0 13^1-15^1 N and longitude 6^0 36^1-40^1 E of the North Western quadrant of the Rivers State of Nigeria. The area which is made up of Ogba/Egbema/Ndoni, Ahoada-East, Ahoada-West, Emuoha, Ikwerre, local governments of Rivers State are within Oil Mining License (OML) 58 (Total Fina Elf) and Oil Mining License (OML) 61, Nigerian Agip Oil Company (NAOC) 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.

Literature Review

One of the three goals of the United Nations for sustainable food security is to ensure that all people have access to sufficient, nutritionally adequate and safe food (Jibiri *et al*., 2007). Natural radioactive elements are transferred and cycled through natural processes and between the various environmental compartments by entering into ecosystems and food chains. Vegetables may be subjected to direct and indirect contamination of uranium series radionuclide. Use of fertilizers leads to elevation of uranium series nuclides in vegetables. Naturally Occurring Radio-nuclides (NORM) of Th and U are significant contribution of ingestion dose and are present in the biotic systems of plants, animals, soil, water and air.

Distribution of those radio-nuclides in different parts of the plant depends on the chemical characteristics and several parameters of the plant and soil (Shanthi *et al*., 2009). Olomo (1990) study's on natural radioactivity in some Nigeria foodstuffs examined, varies and concluded that the major factor that may be responsible include, application of fertilizer, soil type and irrigation pattern. Arogunjo *et al*. (2004) studied the level of natural radionuclide in some Nigerian cereals and tubers using HpGe detector and reported average concentration of ^{40}K, ^{238}U and ^{232}Th as 130+8.12 Bqkg^{-1}, 11.5+3.86 Bqkg^{-1}, and 6.78+2.13 Bqkg^{-1} respectively, while ^{137}Cs was not detected in any of the food stuffs analyzed. Eyebiokin *et al*. (2005) also studied the activity concentrations and absorbed dose equivalent of commonly consumed vegetables in Ondo state using Nal(IL) detector and reported that mean effective dose equivalent for Akure, Idanre and Agbabu were 0.59 mSvy^{-1} 0.73 mSvy^{-1} and 0.64 mSvy^{-1} respectively. They concluded that the values obtained are lower than the UNSCEAR (1993) recommended value for normal background. Ojo and Ojo, (2007) on the radiological study of brackish and fresh water food samples in Lagos and Ondo States, they reported that the average concentration of 50.92+7.04 Bqkg^{-1} ^{238}U and 24.60+6.47 Bqkg^{-1} ^{232}Th were found to be higher in brackish water while ^{40}K (738.94+84.81 Bqkg^{-1}) was found to be higher in food samples got from fresh water.

Mlwilo *et al*. (2007) study on radioactivity levels of staple foodstuffs and dose estimates for most of the Tanzanian population revealed that the average activity concentration of ^{40}K, ^{232}Th and ^{238}U in maize were 48.79+0.11, 4.08+0.01 and 13.23+0.10 BqKg^{-1} respectively and in rice 3.82+0.02, 5.02+0.02 and 24.67+0.03 BqKg^{-1} respectively. He concluded that the relatively high average concentrations of the radio-nuclides in maize compared to rice may be attributed to the extensive use of phosphate fertilizers in maize production in Tanzania and that the total annual committed effective doses due to total ^{232}Th and ^{238}U intakes as a result of consumption of staple foodstuff for infants, children and adults were 0.16, 0.29 and 0.36 msvyr^{-1} respectively, which are lower than the annual dose guideline for the general public. Activity concentrations of ^{226}Ra, 228Th, ^{40}K in different food crops from a high background radiation area in Bitsichi, Jos Plateau, Nigeria were studied by Jibiri *et al*. (2007). The activity concentration in the food crops ranged below detection limit (BDL) to 684.5 BqKg^{-1} for ^{40}K from BDL to 83.5 BqKg^{-1} for ^{225}Ra, and from BDL to 89.8 BqKg^{-1} for 228Th. It was further revealed that activity concentrations of these radionuclides were found to be lower in cereals than in tubers and vegetables.

The average external gamma dose rates were found to vary across the farms from 0.50+0.01 to 1.47+0.04 uSrh^{-1}. Because of the past mining activities in the area, it was found that the soil radioactivity has been modified and the concentration level of the investigated natural radio-nuclides in the food crops has been enhanced but however, the values obtained suggested that the dose from intake of these radio-nuclides by the food crops is low and that harmful health effects are not expected.

Shanthi *et al*. (2009) carried out a study to evaluate the radioactivity concentration in the food crops grown in high-level natural radioactive area (HLBRA) in South–West India. The calculated daily intakes of these radio-nuclides isotope (^{226}Ra, ^{228}Ra, ^{228}Th and ^{40}K) using concentrations in south Indian foods and daily consumptions of these foods were fund to be ^{226}Ra, 0.001-1.87, ^{228}Ra, 0.0023-1.26, 228Th,0.01-14.09, ^{40}K, 0.46-49.39 Bq/day. It was concluded that the daily internal dose resulting from ingestion of radionuclides in food was 4.92 uSv/day and the annual dose was 1.79 mSvyr^{-1}. In view of the potentially dangerous effects of radioactive substances, no effort should be spared in their quantitative determination in all the identifiable pathways.

Materials and Methods

A large sample of local food crops/stuffs mainly cereals, vegetables, fruits and tubers were purchased from various markets where they were produced in all the zones under study. The zones were selected based on their common culture and markets existing within them. Measurements were carried out with Digilert Nuclear Radiation Monitoring meter (Radalert-100) and the Global positioning system (GPS 76 CSX) handheld equipment for the measurement of the geographical coordinates of the sample points and stop clock for timing. An *in-situ* approach of measurement was preferred and adopted, this is to enable samples maintain their original characteristics. Measurement procedure and method used was that of (Avwiri *et al*., 2007), (Arogunjo *et al*., 2005). Readings were obtained between the hours of 1200 and 1600, since the exposure rate meter has a maximum response to environmental radiation within these hours (Louis *et al*., 2005).The Radalert–100 is a health and safety instrument that measures alpha, beta, gamma and x-ray radiation. It uses a Geiger-Muieller Tube (GM) to detect radiation. The GM-tube generates a pulse of electrical current each time radiation passes through the tube and causes ionization. Each pulse is electronically detected and registered as a count. The Radalert-100 was characterized and set to the exposure rate-made to measure the radiation level directly, which was displayed in milli Roetgen per hour ($mRhr^{-1}$). The average meter readings and dose equivalent were calculated using the appropriate formula to estimate the whole body equivalent dose recommended by the National Council of Radiation Protection and measurement (NCRP, 1993) which stipulates that ImRhr-^{1}= (76x0.7) $mSvyr^{-1}$

Data Presentation

The Mean Exposure Rate and Equivalent Dose for all Food Crops in the Study Area (Zone A to Zone F)

The Mean Exposure Rate and Equivalent Dose for all food crops are presented in Table 3a-3b below:

Discussion

An *insitu* method of radiation levels measurement conducted within OML 58 and OML 61 of parts of the Niger Delta Region areas were divided into six (6) zones (Zone A,B,C,D,E,F, respectively). The average exposure levels

Table 1. Background Radiation levels of the study area

Zone	Name	Geographical Location	Radiation levels ($mRhr^{-1}$)			Average Radiation level ($mRhr^{-1}$)	Equivalent Dose ($mSVyr^{-1}$)
			1	2	3		
A	Obrikom/Ebocha /Mgbede	05 23.631 06 40.189	0.014	0.011	0.011	0.013±0.001	0.692±0.062
B	Omoku/Obite/Akabuka/ Obagi	05 20. 694 06 39. 411	0.015	0.014	0.014	0.015±0.001	0.798±0. 065
C	Ahoada/Edoha/Abua	05 04. 546 06 39.272	0.013	0.015	0. 015	0.015±0.011	0.798±0.065
D	Elele/Ikiri/Umuduga	05 06. 215 06 48. 710	0.009	0.014	0.014	0.011±0.001	0.585±0.041
E	Elele-Alimini/Ndele	05 03.255 06 43.719	0.012	0.015	0.015	0.014±0.001	0.745±0. 045
F	Mbiama/Engenni Community	05 03.855 06 26.901	0.015	0.014	0.014	0.015±0.001	0.798±0.065
	Mean value					0.013±0.001	0.736±0.057

Table 2a. The Mean Exposure Rates for Individual Food Crop in the Surveyed Areas

Area Code	**Surveyed Area**	**Mean site Radiation Levels (mRhr^{-1})**			
		Fruits	Tubers	Vegetables	Cereals
A	Obrikom/Ebocha /Mgbede	0.012±0.001	0.014±0.001	0.012±0.001	0.016±0.001
B	Omoku/Obite/Akabuka/Obagi	0. 017±0.001	0.018±0.001	0.014±0.001	0.016±0.001
C	Ahoada/Edoha/Abua	0.013±0.001	0.016±0.001	0.013±0.001	0.015±0.001
D	Elele/Ikiri/Umuduga	0.014±0.001	0.019±0.001	0.013±0.001	0.013±0.001
E	Elele-Alimini/Ndele	0.013±0.001	0. 018±0.001	0.012±0.001	0.013±0.001
F	Mbiama/Engenni Community	0.010±0.001	0.014±0.001	0.011±0.001	0.011±0.001
	MEAN VALUE	**0.013±0.001**	**0.017±0.001**	**0.013±0.001**	**0.014± 0.001**

Table 2b. Mean Equivalent Dose for individual food crop in the surveyed Areas.

Area Code	Surveyed Area	Mean site Equivalent dose (mRhr^{-1})			
		Fruits	**Tubers**	**Vegetables**	**Cereals**
A	Obrikom/Ebocha /Mgbede	0.628±0.048	0.718±0.050	0.638±0.051	0.851±0.071
B	Omoku/Obite/Akabuka/ Obagi	0. 894±0.071	0.931±0.073	0.745±0.054	0.825±0.071
C	Ahoada/Edoha/Abua	0.681±0.053	0.865±0.063	0.702±0.054	0.772±0.063
D	Elele/Ikiri/Umuduga	0.745±0.061	0.011±0.331	0.670±0.045	0.665±0.057
E	Elele-Alimini/Ndele	0.681±0.057	0. 944±0.082	0.617±0.038	0.665±0.043
F	Mbiama/Engenni Community	0.553±0.047	0.718±0.052	0.596±0.046	0.585±0.041
	MEAN VALUE	**0.697±0.056**	**0.866±0.053**	**0.661±0.048**	**0. 727± 0.058**

determined for zone A (Obrikom/Ebocha/Mgbede) ranges between 0.009 mRhr^{-1} (0.479 mSvyr^{-1}) in pumpkin, *corchonis olitorius)* to 0.020 mRhr^{-1} (1.064 mSvyr^{-1}) in both corn, *zea mays and Okro, Abelmostars Esculentus*. For zone B (Omoku/ Obite/Akabuka/Obagi), the average exposure levels determined ranges between 0.010mRhr^{-1}(0.585 mSvyr^{-1}) in Pepper, *Piper nigrum* to 0.022 mRhr^{-1} (1.170 mSvyr-1) in orange, *citrus spp.* For zone C (Ahoada/Edoha/Abua), the average exposure levels determined ranges from 0.010mRhr^{-1} (0.532 mSvyr^{-1}) in Pepper, *Piper Nigrum* to 0.025 mRhr-1 (1.330 mSvyr^{-1}) in sweet Potato, *Ipomoea Batatas.* For zone D (Elele/Ikiri/Umudioga), the average exposure levels determined ranges from 0.010 mRhr^{-1} (0.532 mSvyr^{-1}) in pawpaw, *carica papaya* to 0.028 mRhr-1 (1.490 mSvyr^{-1}) in sweet Potato, *Ipomoea batatas.* For zone E (Elele-Alimini/Ndele), the average exposure levels determined ranges from 0.005 mRhr^{-1} (0.266 mSvyr^{-1}) in orange, *Citrus spp* to 0.022 mRhr-^{1} (1.170 mSvyr^{-1}) in yam. *Discorea spp.*

For zone F (Mbiama/Engenni community), the average exposure levels determined ranges from 0.006 mRhr^{-1} (0.319 mSvyr^{-1}) in orange, *citrus spp* to 0.016 mRhr^{-1} (0.851 mSvyr-^{1}) in Yam, *Dioscorea spp.* Table 1 shows the exposure rate determined for the background radiation levels for the six zones which ranges from 0.011 mRhr^{-1} (0.585 mSvyr^{-1}) in zone D, (Elele/Ikiri/Umodioga) to 0.015 mRhr^{-1} (0.798 mSvy^{-1}) in zone B and F respectively. Table 2a show the mean exposure rate determined for individual food crops. The average exposure rate ranges from 0.013mRhr^{-1} (0.697 mSvyr^{-1}) in fruits to 0.017 mRhr^{-1} (0.866 mSvyr^{-1}) in Tubers. Table 3 shows mean exposure rate for all food crops which ranges from 0.012 mRhr^{-1} (0.613 mSvyr^{-1}) in zone F (Mbiama/Egenni Community) to 0.016 mRhr^{-1} (0.849 mSvyr^{-1} in zone B (Omoku/Obite/Akabuka/Obagi. Table 4 show the comparison of average exposure rate for all food crops investigated with average background exposure radiation levels. The lowest average radiation exposure rate of 0.011 mRhr^{-1} was obtained at zone D (Elele/Ikiri/Umodiaga), which may be due to low level of oil and gas activities

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Table 3a. Mean Exposure rate for all food crops

Area Code	Surveyed Area	Mean site Radiation Levels (mRhr^{-1})				Mean exposure Rate for all Crops (mRhr^{1})
		Fruits	Tubers	Vegetab-les	Cereals	
A	Obrikom/Ebocha /Mgbede	0.012 ±0.001	0.014 ±0.001	0.012 ±0.001	0.016 ±0.001	0.014 ± 0.001
B	Omoku/Obite/Akabuka/ Obagi	0. 017 ±0.001	0.018 ±0.001	0.014 ±0.001	0.016 ±0.001	0.016 ± 0.001
C	Ahoada/Edoha/Abua	0.013 ±0.001	0.016 ±0.001	0.013 ±0.001	0.015 ±0.001	0.014 ±0.001
D	Elele/Ikiri/Umuduga	0.014 ±0.001	0.019 ±0.001	0.013 ±0.001	0.013 ±0.001	0.015 ±0.001
E	Elele-Alimini/Ndele	0.013 ±0.001	0. 018 ±0.001	0.012 ±0.001	0.013 ±0.001	0.014 ± 0.001
F	Mbiama/Engenni Community	0.010 ±0.001	0.014 ±0.001	0.011 ±0.001	0.011 ±0.001	0.012 ±0.001

Table 3b. Mean Equivalent Dose for all food crops

Area Code	Surveyed Area	Mean site Radiation Levels (mRhr^{-1})				Mean equivalent dose for all food crops (mRhr^{-1})
		Fruits	Tubers	Vegetab-les	Cereals	
A	Obrikom/Ebocha /Mgbede	0.628 ±0.048	0.718 ±0.050	0.638 ±0.051	0.851 ±0.071	0.709 ± 0.055
B	Omoku/Obite/Akabuka/ Obagi	0. 894 ±0.071	0.931 ±0.073	0.745 ±0.054	0.825 ±0.071	0.849 ± 0.067
C	Ahoada/Edoha/Abua	0.681 ±0.053	0.865 ±0.063	0.702 ±0.054	0.772 ±0.063	0.755 ±0.058
D	Elele/Ikiri/Umuduga	0.745 ±0.061	0.011 ±0.331	0.670 ±0.045	0.665 ±0.057	0.773 ±0.124
E	Elele-Alimini/Ndele	0. 681 ±0.057	0. 944 ±0.082	0.617 ±0.038	0.665 ±0.043	0.727 ± 0.055
F	Mbiama/Engenni Community	0.553 ±0.047	0.718 ±0.052	0.596 ±0.001	0.585 ±0.041	0.613 ±0.047

Table 4. Comparison of Exposure rate for all food crops with Background Radiation levels

Area Code	Survey Area Name	Mean Site Radiation Level for all crops (mRhr^{-1})	Mean Background Radiation levels for zone (mRhr^{-1})
A	Obrikom/Ebocha /Mgbede	0. 014± 0.001	0.013 ± 0.001
B	Omoku/Obite/Akabuka/ Obagi	0.016 ± 0.001	0.015 ±0.001
C	Ahoada/Edoha/Abua	0.014 ± 0.001	0.015 ± 0.001
D	Elele/Ikiri/Umuduga	0.015 ± 0.001	0.011 ± 0.001
E	Elele-Alimini/Ndele	0.014 ± 0.001	0.014 ± 0.001
F	Mbiama/Engenni Community	0.012 ± 0.001	0.015 ± 0.001

Table 5. Comparison of Equivalent dose calculated for surveyed Area and background radiation with the National standards

Area Code	Surveyed Area Name	Mean background Dose (mRhr^{-1})	Mean Equivalent Dose rate for all crops (mSVyr^{-1})
A	Obrikom/Ebocha /Mgbede	0.692 ±0.062	0.709 ±0.055
B	Omoku/Obite/Akabuka/ Obagi	0.798 ±0.065	0.849 ± 0.067
C	Ahoada/Edoha/Abua	0.798 ±0.065	0.755 ± 0.058
D	Elele/Ikiri/Umuduga	0.585 ±0.041	0.773 ± 0124
E	Elele-Alimini/Ndele	0.745 ± 0.045	0.727 ± 0.055
F	Mbiama/Engenni Community	0.798 ±0.065	0.613 ± 0.047

within the zone compared with the highest average radiation exposure rate of 0.015 mRhr^{-1} obtained in zone B (Omoku/Obite /Akabuka/Obagi) which is the area of operation of NAOC (OML 61). The results of the exposure rate of all food crops sampled and investigated showed that 45 food crops samples which represent 46.8% of all the food crops collected and investigated exceeded the normal background level of 0.013 mRhr^{-1} (ICRP standard). But these values obtained are within the range previously reported by Avwiri and Agbalagba (2007), Arogunjo *et al*. (2004), Avwiri

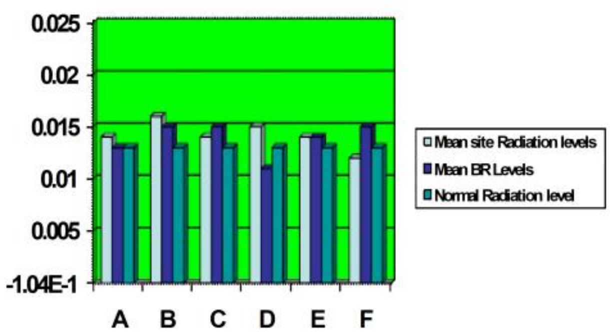

Fig. 1. Comparison of measured radiation levels for all Crops with normal background Radiation Levels

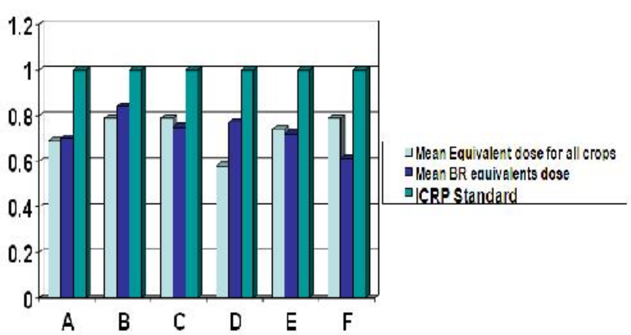

Fig. 2. Comparison of the calculated equivalent dose with the ICRP standard of equivalent dose

and Ononuogbo (2010) in the Niger Delta Region. The maximum exposure rate of 0.028mRhr-^{1} recorded in sweet potato, *Ipomoea batatas* in Zone D (Elele/Ikiri/Umudioga) could be due to application of potassium based fertilizer in improvement of food crop yield which is prevalent in the area. It could also be due to the high water content of tubers, which tend to accumulate soluble radio-nuclides. The result of the computed mean effective equivalent dose rate for the six zoned areas (Table 3.5) are 0.709 ± 0.055 mSVyr^{-1}, 0.849±0.067 mSVyr^{-1}, 0.755±0.058 mSVyr^{-1}, 0.773±0.124 mSVyr^{-1}, 0.727±0.055 mSVyr^{-1} and 0.613±0.047 mSVyr^{-1} respectively. These values obtained are within the dose limit of ImSvyr^{-1} for the public and 20 mSVyr^{-1} for radiological workers recommended by International Commission on Radiological Protection (ICRP).

Figures 1 & 2 shows a comparison of the mean site (sample) equivalent and mean BR equivalent dose with the national acceptable equivalent dose limit. It shows that all the calculated equivalent doses from both samples and the area under study are very close to the safe limit of ImSvyr^{-1} for the public. At Zone D (Elele/Ikiri/Umudioga), the mean equivalent dose calculated was 1.011± 0.331 mSVyr^{-1} that is far greater than the permissible limit for the public but within the safe limit for the radiological workers. Since the equivalent dose rate of 1.011 mSVyr^{-1} is slightly higher than the basic safety standards allowed limits for the public, it therefore implies that the environment is becoming unsafe and continuous consumption of these food crops by the general populace in the study area is posing danger on a daily basis. Relevant checks on this trend are therefore necessary by all stakeholders.

Conclusion

A preliminary assessment of Naturally Occurring Radioactive Material (NORM) containing food crops within OML 58 and OML 61 in the Niger Delta Region has been carried out using the *insitu* measurement approach. This was mean to determine the background ionization radiation level of the study area and the food crops samples. The study revealed a rising radiation level though within the acceptable limit for the public and within the safe limit for radiological workers. The equivalent dose rate obtained for all food-crops sampled did not exceed the safe limit recommended by the international bodies on radiation protection except in few samples where slight elevation above the recommended safe limit was observed. Other analytical methods of ascertaining the exposure rate at various sites and samples such as Exploranium GR-135 to identify the different radionuclide isotopes present in the samples and Hyper Pure Germanium (HyGe) detector to know the specific radionuclides responsible for the contamination/pollution of these foodstuffs is hereby recommended.

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