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Determination of Excess Lifetime Cancer Risk Due to Gamma Radiation in Some Agricultural Products Obtained From Two Oil Fields in the Niger Delta Region of Nigeria

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Abstract: ***Radioactivity measurements for naturally occurred radionuclides of ^{40}K, ^{226}Ra, ^{228}Ra were carried out in some agricultural products harvested from two oil fields within the Nigeria Delta Region of Nigeria. The values obtained were used to determine the excess lifetime cancer risk (ELCR) and the radiation health hazard indices. Results show that the mean calculated ELCR values obtained from vegetables ranged from 0.049 x 10^{-3} – 0.105 x 10^{-3}, mean 0.68 x 10^{-3}, for fruits, 0.035 x 10^{-3}–0.088 x 10^{-3}, mean 0.056 x 10^{-3}, absorbed dose D (nGyh^{-1}) in vegetables ranged from 11.05 – 15.52 mean 13.07, for fruits, it ranged from 8.19 -12.34, mean 10.39.Mean Specific Activity values obtained for ^{40}K,^{226}Ra,^{228}Ra in Vegetables are 95.95± 18.85 Bqkg^{-1}, 10.79 ± 3.46 Bqkg^{-1}, 6.83 ± 2.32 Bqkg^{-1}and in fruits, the Mean Specific Activity values for ^{40}K, ^{226}Ra, ^{228}Ra, 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 overall results obtained agreed with other earlier works in Nigeria and all over the world (Arogunjo et al., 2005, Olomo., 1990, Shanthi et al., 2009., Mlwilo et al., 2007; Jibiri et al., 2007, Badaret al.,2003,Baeza et al.,2001 etc). All the above listed mean values had earlier been reported (Avwiri et al, 2013). With all these results all values obtained were less than the world permissible standards. It could therefore be concluded that the potential carcinogenic risk from gamma radiation doses obtained in this work is low.***

Keywords: Excess Lifetime Cancer Risk (ELCR) Gamma Radiation, Agricultural Products, Hazard Indices

1. Introduction

The estimation of exposure of humans to the various sources of radiation is very important (EL-Taher and Uosif, 2006). Humans have been exposed to radiation from natural sources since the dawn of time. The sources include the ground we walk on, the air we breathe, and the food we eat. (Ramiza, M.Y *et al*., 2010), Radionuclide when ingested or inhaled enter the human body and are distributed among body organs according to the metabolism of the element involved. The organs normally exhibit varying sensitivities to radiation and thus varying doses and risks result from their consumption or inhalation (UNESCEAR, 1993) with the widespread of natural radioactivity in the earth's environment, a nuclear radiation can pass through a living well which lead to both excitation and ionization that can alter the structure of cells. These cells may be damaged directly by radiation or indirectly by the free radicals (OH) and (H) produced in the adjacent cells.

(Emelue, H.U. *et al*., 2014). Many forms of damage could occur from radiation but the most important is that due to the deoxyribonodeic acid (DNA). Any damage to the DNA results in gene mutation, chromosomal aberration and breakapes or cell death. Explosive to ionizing radiation over extended period can result in non-leather mutation which can cause the risk of cancer (NCRP, 1993). There is a linear-no-threshold (LNT) relationship between radiation dose and the occurrence of cancer. This dose- response hypothesis suggests that any increase in radiation dose, no matter how small, could results in cancer risk (Emelue*et al*., 2014). Some of the diseases linked to exposure by radioactivity are kidney cancers, lung cancer, atrophy of the kidney, cataracts, sterility and leukemiae.t.c (Taskin*et al*., 2009).

Therefore excess lifetime cancer risk is the probability that an individual will develop cancer over his or her lifetime of exposure. The research examined the health hazard indices and the cancer risk due to the consumption of these agricultural products in an oil bearing environment.

2. Study Area

The study area is within two oil fields (OML 58 and OML 61) in the Niger Delta Region of Nigeria. It is slated approximately between latitudes 5^0 13-28 x N and longitude 6^0 35'-42' E of the North Western guardant of Rivers State of Nigeria. The area is made up of Ogba/Egbema/Ndoni, Ahoada-East, Ahoada-West, Emuoha and Ikwere Local Government of Rivers State. Prominent towns and communities within the study area are Omoku, Elele-AlimniMbiama, Engenni community, Ebocha, Obrikom, Mgbede and By-Elele (figure 1) this was as earlier reported in (Avwiri*et al*., 2013).

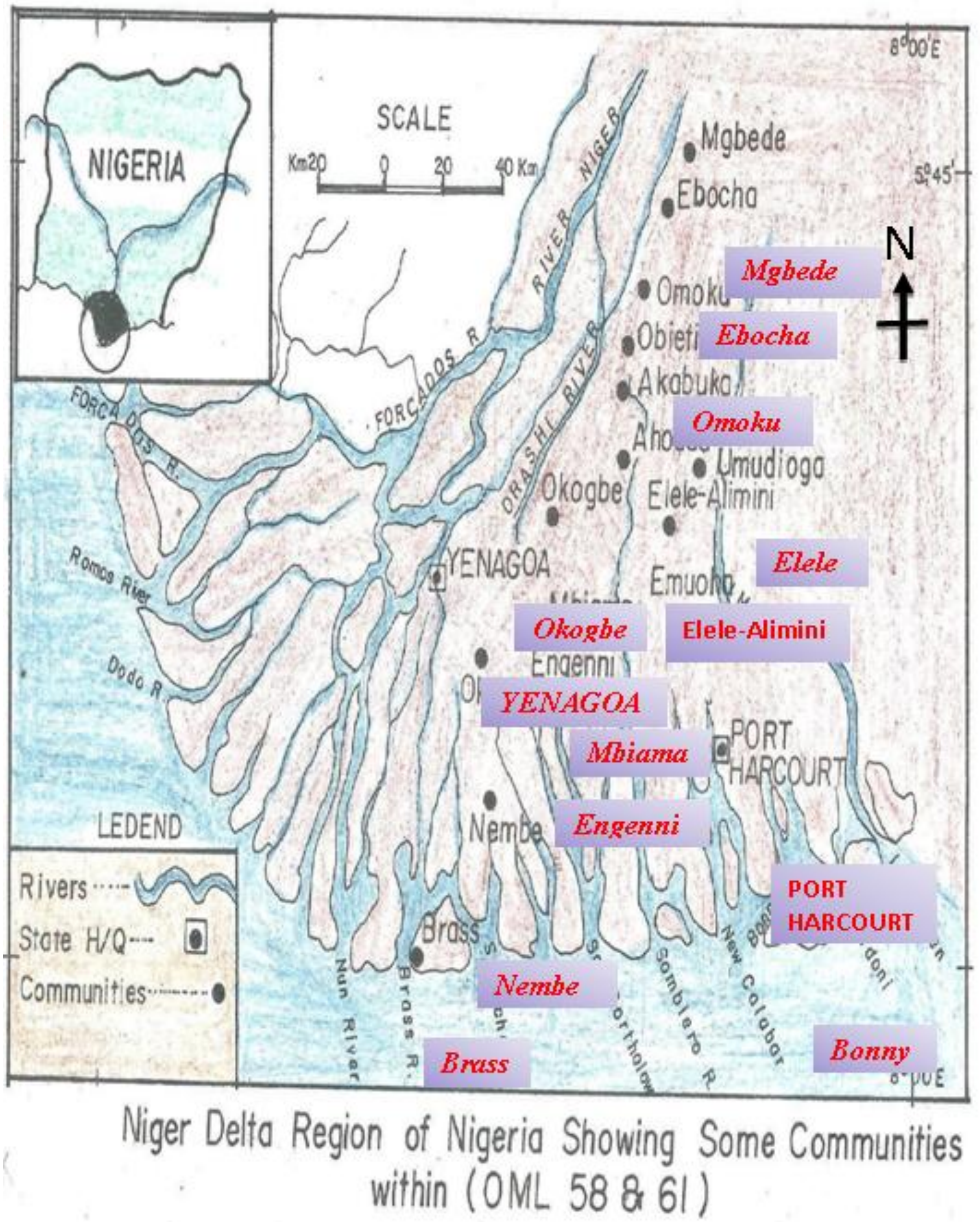

Figure 1: Map of the study area

3. Materials and Methods (Avwiri*et al*., 2013)

As reported in Avwiri*et al*., 2013, study area was divided into six zones (A,B,C,D,E,F) and a total of thirty one (31) samples containing twenty (20) vegetables and eleven (11) fruits were harvested and collected from agricultural farms and garden where they were produced. Several kilograms of each type of vegetable surveyed (pumpkin leaf and seed, okro, waterleaf) were collected. The vegetation was held in the hand while being cut to a height at which grazing takes place. They were dried to a constant weight and reduced to powder form by crushing. For the fruits surveyed (orange and plantain), they were peeled and together with the peels, they were grounded before being sealed. All samples were further dried at room temperature at constant weight, powdered and sieved to pass through 2mm mesh and sealed in pre-treated I-L, Marinelli beakers for at least 28 days for secular equilibriumto set-in before gamma spectroscopy analysis. 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 (Nal (TI) Detector, Model-Bircom Preamplifier Model 2001, Amplifier Model 2020, ADC Model 8075, HVPS Model 3105). 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, ObafemiAwolowo University, Ile-Ife where these samples were analysed. The technique used are well described elsewhere (IAEA, 1984, Tchokossa*et al*., 2011). The MCA was calibrated so as to display gamma photo peaks in the energy range of 200 – 3000 Kev, this being the energy range for radionuclides of interest identified with reliable regularity. The counting time was 3600s. The activity concentrations (c) in $Bqkg^{-1}$ of the radionuclides in the samples was calculated after decay correction using the expression(Zarie and Al Mugren, 2010).

$$Cs = \frac{N_{Ey}}{\varepsilon E\gamma \times Ms \times tc \times P\gamma} \ (Bqkg^{-1})$$

where C_s = Sample concentration, $N_{Ey=}$ net peak area of a peak at energy, ε_{Ey}= efficiency of the detector for a γ-energy of interest, M_s=sample mass, t_c= total counting time, P_γ=emission probability of radionuclide of interest.

4. Data Presentations/Results

- **Activity Concentration of ^{40}K,^{238}U (^{226}Ra) and ^{232}Th (^{228}Ra):**
  The values of activity concentrations of the above natural radionuclides as obtained for vegetables and fruits are as shown in Tables 1 and 2 and earlier reported in (Avwiri*et al.,* 2013).

- **Absorbed Dose Rate (D):**
  Absorbed dose rate is the measure of the amount of radionuclides absorbed by the human body for a given period. The absorbed dose rates in outdoor (D) due to gamma radiation in air at 1m above the ground surface for the uniform distribution of the naturally occurring radionuclides were calculated based on guidelines provided by UNSCEAR, 2000. The conversion factors used to compute absorbed gamma dose rate (D) in air per unit activity concentration in Bq/kg corresponds to $0.462nGh^{-1}$ for ^{226}Ra (of U-series), $0.621nGyh^{-1}$ for ^{232}Th and $0.0417\ nGh^{-1}$ for ^{40}K (UNSCEAR, 2000, Ashraf *et al.*, 2001).
  $D = 0.462C_{Ra} + 0.621C_{Th} + 0.0471C_k$ ($nGyh^{-1}$) for this work is from 11.05 $nGyh^{-1}$ to $15.52nGyh^{-1}$ (mean = $13.07nGyh^{-1}$) for vegetables (Table 1) fruits is from $8.19nGyh^{-1}$ to $12.34nGyh^{-1}$ (mean = $10.39nGyh^{-1}$) respectively. Table 2

- **The Annual Effective Dose Equivalent (AEDE):**
  The annual effective dose equivalent received by human is calaculated from the absorbed dose rate by applying dose conversion factor of 0.7 Sv/Gy and the occupancy factor for outdoor and indoor was 0.2 (5/24) and 0.8 (19/24), respectively (Ramasamy*et.al*., 2009, Vetga*et al.*, 2006). The annual effective dose was determined using the following equations:
  AEDE (outdoor) = Absorbed dose ($nGyh^{-1}$) x 8760h x 0.7 sv/G x 0.2 x 10^{-3} (µsv/y).
  AEDE (indoor) = Absorbed dose $nGyh^{-1}$ x 8760h x 0.7 sv/Gy x 0.8 x 10^{-3} (µsv/y).
  The calculated effective dose for vegetables is from 0.014 $mSvy^{-1}$ to 0.030 $msvy^{-1}$ (mean $0.020msvy^{-1}$) Table 1 and 0.010 $mSvy^{-1}$ to $0.025mSvy^{-1}$ (mean 0.016 $mSvy^{-1}$) for fruits. Table 2 respectively.

- **Excess Lifetime Cancer Risk (ELCR)**
  The excess lifetime cancer risk deals with the probability of developing cancer over a lifetime at a given exposure life. ELCR is calculated using the below equation:
  ELCR = AEDE x DL x DR (Ramasamy*et al.*, 2009, Emelue*et al.*, 2014)
  Where AEDE is the annual effective dose equivalent
  DL is the average duration of life (estimated to be 70 years)
  RF is the risk factor i.e. fatal cancer risk per sievert

For stochastic effects ICRP uses RF as 0.05 for the public. The result is recorded in Tables 1 and 2 and comparison the values to the world permissible standard of 0.29 x 10-3 is in figures 2 and 3.

- **External Hazard Index (Hex):**

The external hazard index is an evaluation of the outdoor of the natural gamma radiation and is defined using the below equation:

$$Hex = \left(\frac{C_u}{370} + \frac{C_{th}}{259} + \frac{C_k}{4810} \# 1 \right)$$

- **Internal Hazard Index (Hin)**

The internal radiation hazard index was also considered in this work because this could cause respiratory diseases like asthma and cancer (Emelue*et al.*, 2014). This was done using the below equation:

$$H_{in} = \left(\frac{C_u}{185} + \frac{C_{th}}{259} + \frac{C_k}{4810} \# 1 \right)$$

Tables 1 and 2 and figures 2 and 3 shows the values as obtained in this work. It must also be less than unity for the radiation hazard to be negligible which was the case in this work.

Table 1: Mean calculated radiation hazard indices, Effective dose, Excess Life time Cancer Risk (ELCR) of surveyed vegetable samples

Area code	Vegetables			Hazard Indice		
	Surveyed Area	D(nGyh-1)	Effective Dose ($msvy^{-1}$)	Hex	Hin	ELCR x 10^{-3}
A	Omoku/Obite/ Akabuka	14.73	0.018	0.086	0.123	0.063
B	Obrikom/Ebocha/Mgbede	11.05	0.030	0.063	0.086	0.105
C	Ahoada/Okogbe	13.99	0.023	0.063	0.083	0.081
D	Big Elele/Umudioga	11.43	0.014	0.089	0.086	0.049
E	Elele Alimini	11.67	0.014	0.059	0.086	0.049
F	Mbiama/ Engenni Community	15.52	0.018	0.086	0.125	0.063

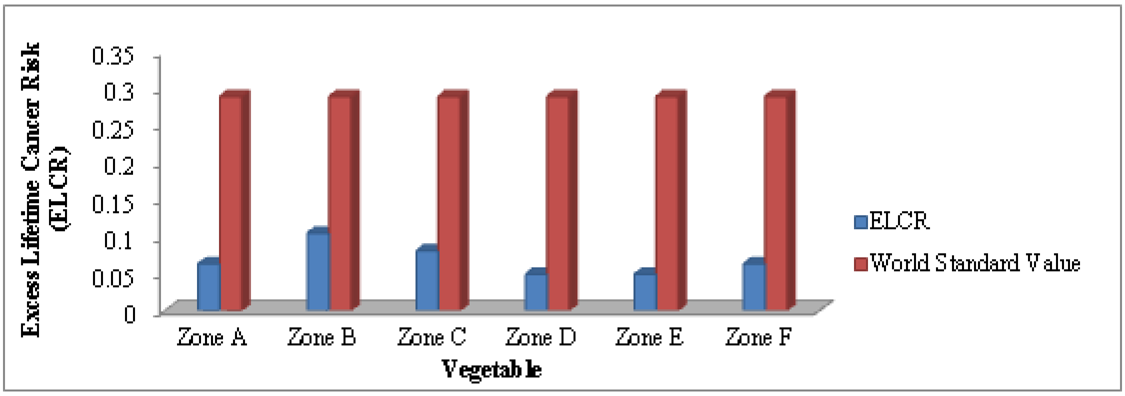

Figure 2: Calculated Excess Lifetime Cancer Risk (ELCR) in Vegetables and Comparison with the World Value

Table 2: Mean calculated radiation hazard indices, Effective dose, Excess Life time Cancer Risk (ELCR) of surveyed fruit samples

Area code	Fruits			Hazard Indices		
	Surveyed Area	D($nGyh^{-1}$)	Effective Dose ($mSvy^{-1}$)	Hex	Hin	ELCR X 10^{-3}
A	Omoku/Obite/ Akabuka	8.19	0.010	0.054	0.074	0.035
B	Obrikom/Ebocha/ Mgbede	9.46	0.012	0.055	0.074	0.042
C	Ahoada/Okogbe	12.31	0.015	0.071	0.081	0.053
D	Big Elele/ Umudioga	12.34	0.015	0.071	0.098	0.053
E	Elele Alimini	11.83	0.020	0.059	0.084	0.070
F	Mbiama/Engenni Community	8.19	0.025	0.056	0.076	0.088

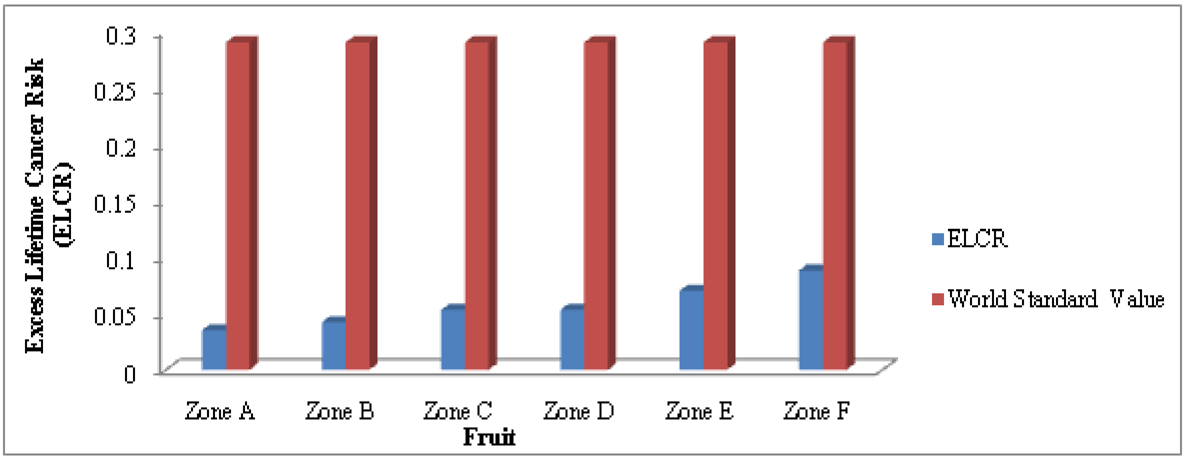

Figure 3: Calculated Excess lifetime Cancer Risk (ELCR) in Surveyed Fruit Samples and Comparison with the World Value

5. Discussion

For agricultural products – vegetables investigated in this study, the calculated values of the external hazard index (Hex) were less than unity which is under the criterion level. Their values ranged from 0.04 to 0.11 with a mean of 0.07. The Excess Lifetime Cancer Risk (ELCR) calculated varied from 0.049 to 0.105, mean 0.068, which is less than the world average of 0.29 (Taskin*et al*., 2009). This average value obtained was in line with 0.095 obtained by (Ramasamy*et al*., 2009) in India. The values of internal index (Hin) ranged from 0.05 to 0.16 with a mean of 0.03. The highest value of 0.11 obtained did not exceed the upper limit which is unity (Zarie and Al Mugren, 2010). With these results the consumption of the agricultural products (vegetables) in this work may not pose immediate radiological impact but long term cumulative effective should be monitored. For agricultural product-fruits, the radiation hazard indices, the external hazard index (Hex) ranged from 0.04 to 0.08 with mean value of 0.06. the highest value of 0.08 obtained did not exceed the upper limit which is unity. The internal hazard index ranged from 0.06 to 0.11 with a mean of 0.08. The Excess Lifetime Cancer Risk (ELCR) calculated varied from 0.035 to 0.070, mean 0.045 which is below the world average. (Taskin*et al*., 2009) figure 3.

6. Conclusion

Summarily, for all the agricultural products surveyed (vegetables, fruits) in this work, these results revealed that the level of pollution observed / calculated could not pose any radiological threat to the populace consuming them as the values obtained when compared to the world permissible values were found below standard and hence the risk of developing cancer by the populace consuming them will be low.

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