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Evaluation of the Gross Alpha and Beta Radioactivity Concentration in Some Agricultural Products (Vegetables and Fruits) Obtained in Two Oil Fields in the Niger Delta Region of Nigeria

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Abstract The gross alpha and beta radionuclide activity concentration in two agricultural products(vegetables and fruits) obtained in selected oil fields within the Niger Delta Region of Nigeria have been studied and evaluated. Vegetables and fruits samples were harvested, collected and analysed for gross alpha and beta activity using an IN-20 model gas-flow proportional counter. The results obtained showed that the average gross alpha and beta activity for vegetables samples ranged from 0.303±0.039 Bg^{-1} to 0.482±0.041 Bqg^{-1} and 0.069±0.055 to 0.880±0.053 Bq/g respectively, while the average gross alpha and beta activity for fruit samples ranged from BDL to 0.561±0.41 Bq/g and 0.164±0.061 to 0.693±0.056 Bq/g respectively. These results revealed an elevation over the activity of the control samples taken from non-oil bearing environment and the World Health Organization standard limit of 0.1Bq/g for gross alpha activity but the average beta activity were all below the WHO standard limit of 1.0 Bq/g in all the zones studied. The elevation recorded may be due to oil exploration activities with associated artificial or anthropogenic activities such as gas flare, pollutants, transportation by air media to plant surfaces, frequent oil spillage into and back to the soil or any accidental underground pollutants into the food chain encountered in the surveyed areas. However, the results so obtained may not pose any serious detrimental health side-effects to the public consuming these products.

Keywords: *Gross Alpha and Beta, Radioactivity, Oil fields, Agricultural products*

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1. Introduction

The need to quantify gross alpha and beta particles content of ingestible materials in human body is necessary as these particles have short ranges and could deposit a lot of energy within a tissue in which they are absorbed. They are inherently charged particles and are capable of causing greater damage due to gross ionization. Radionuclide which enter the human body via foodstuffs, reaches it through a complex mechanism or food chain [3]. The season of the year determines to a great extent the magnitude of contamination of different foods or environmental components [5]. Green leafy vegetables are prone to external contamination during their growing season, while root vegetables may also become contaminated [4]. Vegetables may be subjected to direct and indirect contamination of Uranium series nuclides in vegetables. Naturally occurring Radionuclide (NORM) of Thorium and Uranium are significant contribution of ingestion dose and are present in the biotic systems of plants, animals, soil, water and air. Distribution of these radionuclides in different parts of the plants depends on the chemical characteristic and several parameters' of the plant and soil [7]. Shanthi *et al.*, [7] measured the gross alpha and beta radioactivity in food crops grown in naturally high background radiation areas in South West India and obtained alpha activity to be maximum in tapioca, minimum in Indian Caper (497±72 $Bqkg^{-1}$) (116±14 $Bqkg^{-1}$) and beta activity was maximum in paddy grain (10,946±553 $Bqkg^{-1}$) and minimum in drumstick (190 $BqKg^{-1}$). Olomo, [6] study on natural radioactivity in some Nigeria food stuffs varies and concluded that the major factor 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±2.1 $BqKg^{-1}$ respectively, while ^{137}Cs was not detected I n any of food stuffs analysed. Radionuclides have always been present in food at various levels depending on factors such as radioactivity contents in soil and the transfer characteristics from the environmental medium to foodstuff, and hence to man [3,5,8]. Because of a higher concentration of radioactive substances in the environment and food chain is undesirable, the crux of this research work is to evaluates the gross alpha and gross beta disposition of some agricultural products. (vegetable and fruit) samples within two oil fields in the Niger Delta Region of Nigeria.

2. Study Area

The study area is within two oil fields (OML 58 and OML 61) within the Niger Delta Region of Nigeria. It is situated approximately between latitudes 5^{0} 13^{1}– 28^{1}N and longitude 6^{0} 35^{1}-42^{1}E of the North Western quadrant of Rivers State of Nigeria. The area is made up of Ogba/Egbema/Ndoni; Ahoada-East, Ahoada-West, Emuoha and Ikwere Local governments of Rivers State. Prominent towns and communities within the study area are Omoku, Elele-Alimini; Mbiama, Engennicommunity, Ebocha, Mgbede and Big Elele. (Figure 1).

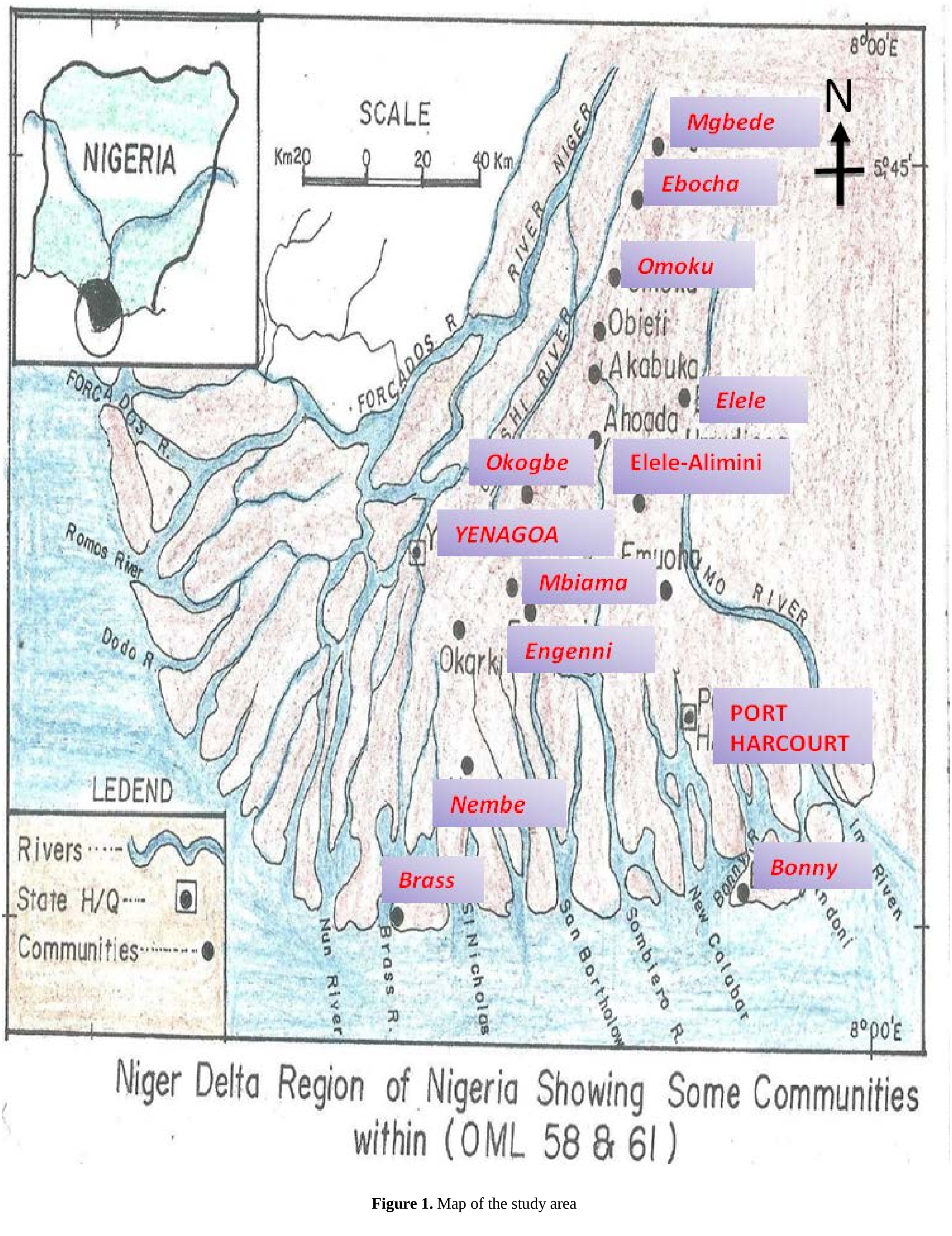

Figure 1. Map of the study area

3. Methodology

3.1. Materials and Methods

Study area was divided into six zones, A,B,C,D,E&F within the two oil fields and total of thirty one samples (twenty vegetables and eleven fruit sample) were collected and spread in containers (properly separated to avoid contamination) and were allowed to dry at room temperature for about ten days. Samples were kept in a slow-air flow temperature of 50°C drying cabinet to help accelerate the drying process without loss of radionuclides from the sample [5]. The dried samples were ground with mortar and pestle and then allowed to pass through a 100-mesh sieve. Prepared samples were pelleted into counting planchet size using the hydraulic compressor machine.

Pelleted samples were kept in desiccators and kept for four weeks to attain a state of secular equilibrium between the respective daughter nuclides of Uranium and thorium.

All the samples were carefully prepared according to International Atomic Energy Agency [5] specifications for gross alpha and beta analysis after which the samples (contained in their panchets) were stored in desiccators awaiting counting.

Analysis were carried out using IN – 20 model gas-flow proportional counter at the Centre for Energy Research and Training,Ahmadu Bello University, Zaria, Nigeria. The operational modes used for the counting were the ∂-only mode for alpha counting and the B (+∂) mode for beta counting. Each sample was counted three times and the mean taken. The count rate of each sample was automatically processed by the computer using the equation (IN-20 Model Technical Manual, 1991) as shown below:

$$C_{(\alpha,\exists)} = R_{(\alpha,\exists)} x60 / t \qquad (1)$$

Where $C_{(\alpha,\beta)}$ = the count rate (cpm) of the alpha or beta particle,
$R_{(\alpha,\beta)}$ = raw cont of the alpha or Beta particle,
t = count time (2700 seconds).
Also the activity of each sample was calculated using the equation (IN-20 Model Technical Manual, 1991);

$$A_{(\alpha,\exists)} = \left[C_{(\alpha,\exists)} - B_{(\alpha,\exists)}\right] x \frac{U_{(\alpha,\exists)}}{3_{(\alpha,\exists)} x S_{(\alpha,\exists)} x V} \qquad (2)$$

Where $A_{(\alpha,\beta)}$ = alpha or beta activity (Bq/L or Bq/g)
$C_{(\alpha,\beta)}$ = count rate of alpha or beta particle
$B_{(\alpha,\beta)}$ = background count of alpha or Beta particle
$U_{(\alpha,\beta)}$ = unit coefficient of alpha or beta.
$3_{(\alpha,\beta)}$ = channel efficiency for alpha or beta counting
$S_{(\alpha,\beta)}$ = sample efficiency for alpha or beta counting
V = sample volume or mass (litre or g)

The error associated with sample activity was computed using (IN-20 Model Technical Manual, 1991);

$$Er = \frac{\left(R + \frac{(100000)^2}{T_{bgd}} XB\right)^2}{100000} X \frac{U}{3XSXV} \qquad (3)$$

Where R = sample raw count, 3 = channel efficiency
Tbgd = background count time, S = sample efficiency
U = unit coefficient (1.67 x 10^{-2}), V = sample volume or mass.

3.2. Data Presentation

Table 1. Average Alpha / Beta Activity (Bq/g) in surveyed vegetable samples for all zones

S/N	Zone	Sample Type	Average Alpha Activity (Bq/g)	Average Beta Activity (Bq/g)
1	A	Vegetable	0.461±0.040	0.069±0.055
2	B	Vegetable	0.482±0.041	0.662±0.055
3	C	Vegetable	0.453±0.040	0.795±0.055
4	D	Vegetable	0.445±0.041	0.636±0.055
5	E	Vegetable	0.303±0.039	0.880±0.053
6	F	Vegetable	0.347±0.041	0.432±0.055

Table 2. Average Alpha / Beta Activity in surveyed fruit samples for all zones

S/N	Zone	Sample Type	Average Alpha Activity (Bq/g)	Average Beta Activity (Bq/g)
1	A	Fruit	BDL	0.164±0.061
2	B	Fruit	0.374±0.041	0.300±0.055
3	C	Fruit	0.247±0.039	0.453±0.058
4	D	Fruit	0.010±0.0420	0.422±0.058
5	E	Fruit	0.330±0.041	0.693±0.056
6.	F	Fruit	0.561±0.041	0.657±0.056

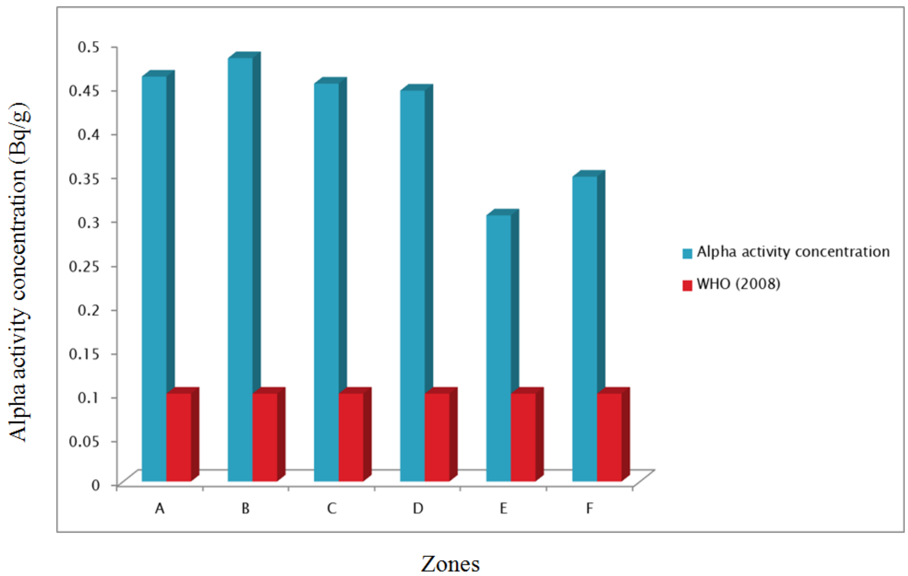

Figure 2. Comparison of alpha activity concentration in vegetable samples for all zones with WHO (2008) standard

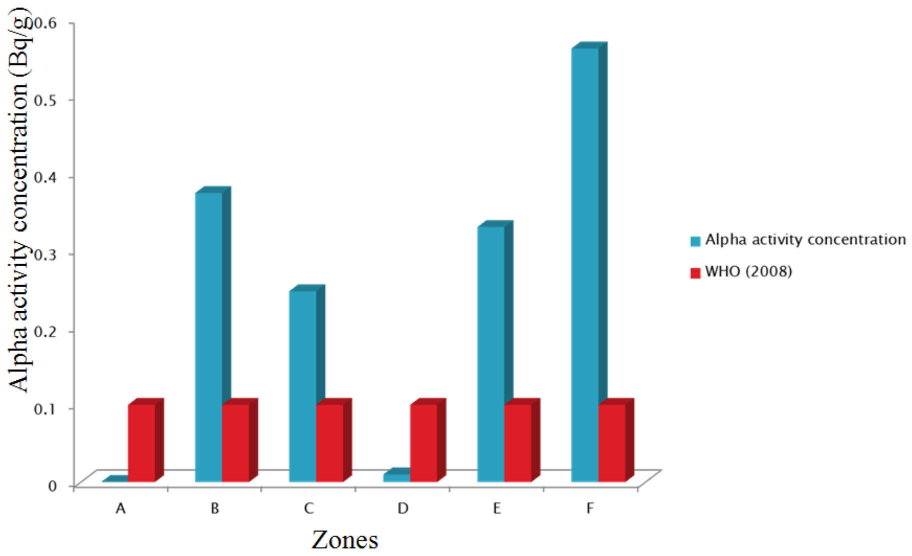

Figure 3. Comparison of alpha activity concentration in fruit samples for all zones with WHO (2008) standard

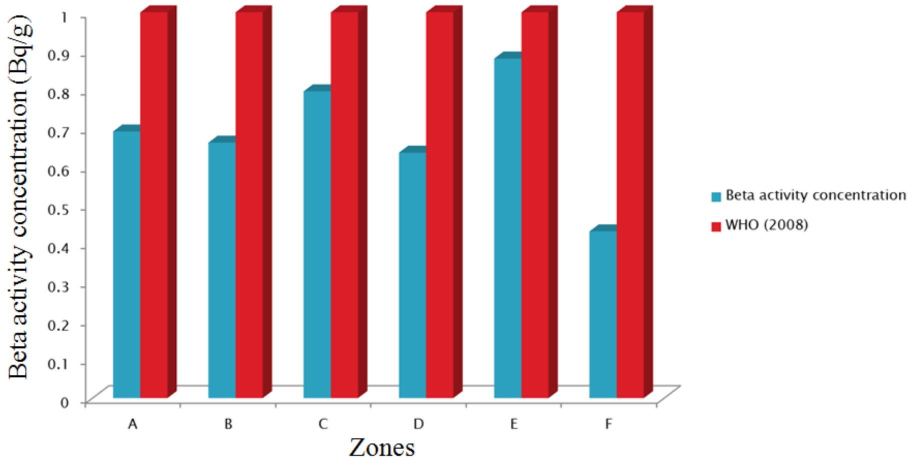

Figure 4. Comparison of Beta activity concentration in vegetable samples for all zones with WHO (2008) standard

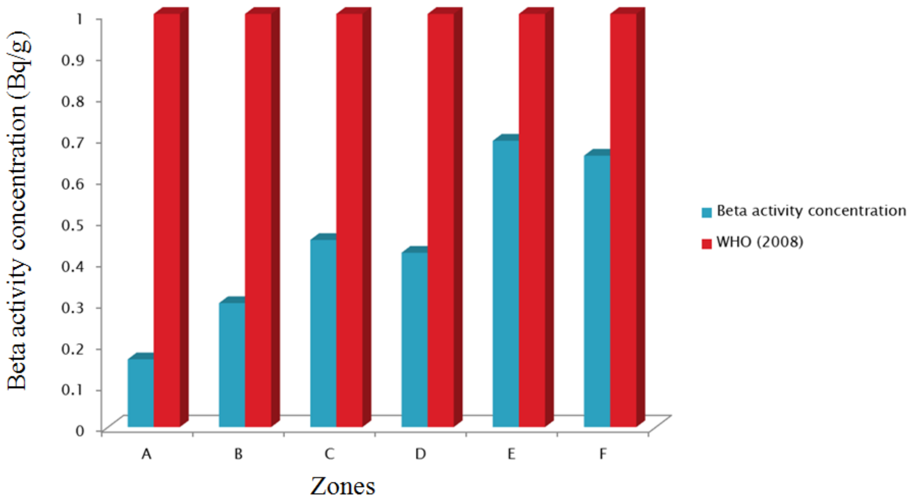

Figure 5. Comparison of Beta activity concentration in fruit samples for all zones with WHO (2008) standard

4. Results and Discussion

4.1. Discussion of Gross Alpha & Beta Activity Concentration in Surveyed Vegetable Samples

Average Alpha Activity Concentration in surveyed vegetable samples ranged from 0.303±0.039 Bqg^{-1}in Zone E to 0.482±0.041Bqg^{-1} in Zone B. while beta activity concentration ranged from 0.432±0.055Bqg^{-1} in Zone F to 0.880±0.053Bqg^{-1} in zone E. The alpha activity concentrations in all the vegetables examined are above the practical screening level of 0.1Bqg^{-1} except in Pumpkin seed, zone A. This may be due to the fact that leafy vegetables seem to absorb more radionuclide like potassium (^{40}K) (Tchokosa*et al*., (2011), Ortega *et al*., (1996). These values obtained are very low compared with Shanthi*et al*., [7] study on food crops grown in South West India with alpha activity concentration of 497±72Bqkg^{-1} obtained in Tapioca. The average beta activity obtained for vegetables in all zones are all within the practical screening level recommended by WHO,2008 though the high elevation value obtained for water leaf in zone A may be due to oil exploration activities with associated artificial or anthropogenic activities in the zone such as gas flare, pollutants transportation by air media to plant surfaces, frequent oil spillage into and back to the soil or any accidental underground pollutant into the food chain, Avwiri*et al.*, (2011) and presence of granitic formation in the geology of the Niger Delta. However, this elevation as obtained here may not pose any danger in its consumption at this stage as a more advanced analysis using gamma stereoscopy is recommended.

4.2. Discussion of Gross Alpha & Beta Activity Concentration in Surveyed Fruits Samples

Alpha activity concentration in surveyed fruit samples ranged from BDL in Plantain and Orange in zone A to 0.561±0.041Bqg^{-1} in Plantain in zone F while beta activity concentration ranged from 0.164±0.061Bqg^{-1} in Plantain, zone A to 0.693±0.056Bqg^{-1} in Orange, Zone E .The BDL for alpha activity obtained in Plantain and Orange in zone A compared with high value in zone F may be attributed to heterogeneity of radionuclide deposited, since it could be greatly influenced by the type of soil, water transportation and man activity in the environment. The average value obtainedfor fruit exceeded the practical screening level stipulated by WHO [10] (Figure 4). In comparison, the gross alpha activity obtained here was far below 80.2±10.1Bqkg^{-1} obtained in banana in South West India [7].

5. Conclusion

The gross alpha and beta activity concentrations in the surveyed samples from the zones vary from location to location. This may be due to the heterogeneity of radionuclide deposited, since it could be greatly influenced by the type of the soil, water transportation, and man activity in the environment etc. The average alpha activity concentration obtained were all higher than the WHO [9] recommended safe limit (0.1 Bq/g) but that of beta activities were all below recommended safe limit by WHO, 2003. The results obtained in this work provide a baseline data on radioactivity contents in some agricultural products in two oil fields in the Niger Delta Region of Nigeria. Finally, all the results obtained revealed that the commonly consumed food crops / stuffs surveyed are safe for consumption without posing any immediate radiological threat to the public as further analysis using gamma stereoscopy is recommended as this will give the activity concentration of the radionuclides. However, inhabitants are cautioned against excessive exposure to avoid further accumulative dose of these radiations.

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