# NATURAL RADIONUCLIDES CONCENTRATIONS IN SOME STAPLE FOOD SAMPLES SOLD IN SAPELE, DELTA STATE, NIGERIA

Uwaoluetan Donald[1], Chukwuka Emmanuel Mokobia[1], Fredrick Oghenebrorie Ugbede[2], Godwin Kparobo Agbajor[1]

1. Department of Physics, Delta State University, Abraka, Nigeria
2. Department of Physics, Dennis Osadebay University, Asaba, Nigeria

*Corresponding author email:uwaoluetandonald123@gmail.com

**Abstract**
Food is an important requirement for man to surviveand as such, its safety must be accorded serious attention. The present study therefore examines the levels of natural radionuclides, $^{40}$K, $^{238}$U and $^{232}$Th, in some samples of food sold in Sapele, Delta state. Results of measured activity concentration in Bqkg$^{-1}$, of the radionuclides indicated a range of 548.74 ± 110.53 in Lemon Grass to 1095.94 ± 210.91 in Okro for $^{40}$K, 21.17 ± 3.59 in Plantain to 67.26 ± 12.28 in Cassava for $^{232}$Th, and 25.22 ± 2.47 in Pepper to 42.36 ± 4.15 in Okro for$^{238}$U. The estimated mean concentration across the foodstuffs was 797.61 ±192.98, 40.75 ±17.84, 32.51 ±5.35 Bqkg$^{-1}$for$^{40}$K,$^{232}$Th and $^{238}$U, respectively, which follows this order, $^{40}$K >$^{232}$Th >$^{238}$U.$^{40}$K contributed highest percentage to the total radioactivity content of the sampled foodstuffs.The noticed high concentration of $^{40}$K in the samples may be attributed to the natural endowment of potassium radionuclide in the earth as well as the possible use of potassium enriched fertilizers by the farmers during the planting period so as to achieve reasonable crop yield.

**Keywords:** Activity concentration; Ingestion exposure; Radiological hazard; Foodstuffs

## Introduction

One of man's most basic requirements is food, and the rising global population has put the world's food security in danger. Therefore, to secure food security for the expanding global population, food production must be increased. Chemical fertilizers are used in agriculture to reclaim land and improve agricultural yield due to this significant demand forthe man(Ononugbo et al., 2019). One important route of internal exposure of humans to radionuclides is through the food chain. Natural radionuclides get transferred to plants along with other micronutrients through the mechanism of soil-plant root interaction and they subsequent get transferred to the human body through ingestion pathway (Ugbede and Akpolile, 2020; Ugbede et al., 2022). The long-lived radioactive elements $^{238}$U, $^{232}$Th, and their decay series, as well as the $^{40}$K, are of principal concern and natural sources of ionizing radiation. Both internal and exterior exposure can result in a radiological danger. Both ingestion and inhalation are ways that radionuclides might reach the human body. The body may have areas where the ingested radionuclides are concentrated. For instance, the human kidney and lungs accumulated $^{238}$U, the liver, lungs, and skeleton tissues accumulated $^{232}$Th, and the muscles accumulated $^{40}$K. Large amounts of these radionuclides depositing in specific organs will have an impact on a person's health by weakening the immune system, causing numerous diseases, and ultimately raising the mortality rate (Tawalbeh et al, 2011). The radionuclide $^{40}$K is the most common naturally occurring radionuclide in foods. Other sources of radionuclides in food include deposited fallout from fission and activation products released after nuclear accidents and components of weapons testing released after the explosion (Tchokossa et al., 2013).

Naturally Occurring Radioactive Materials (NORM) are found in the air we breathe, the food we consume, the soil we walk on, the water we drink, and even within our bodies. Direct deposition of these radionuclides on plant leaves, fruits, tubers, root uptake from contaminated soil or water, and animals ingesting contaminated plants, soil, or water can all cause radioactive contamination of the food chain. Vegetables are an important part of our food, and the presence of radioisotopes like $^{40}$K and those in the $^{226}$Ra and $^{228}$Th series in them has a radiological influence on the people who eat them.(Reebaet al., 2017). The goal of this study is to examine concentrations of natural radionuclides present in certain food samples from Sapele marketplaces in Delta State.The expected results will contribute to the creation of a standardized database of the natural radioactivity of these food samples in Delta state.

## Materials and Method

### Sample Collection and Preparation

In this study, samples of some food stuffs were bought at Sapele main market in Sapele Local Government Area of Delta State, Nigeria. These include,plantain (musa x paradisiacal), cassava (Manihot esculentum linn), melon (cucumis melo), ogbono (irvingiagabonensis), Okro (okra),coconut (Cocos nucifera), pepper (genus Capsicum), and lemon grass (Cymbopogan).For purpose of representative sampling, three replicate samples of each food type were obtained from different sellers, labelled accordingly, and taken to the laboratory for analysis after being prepared. All samples were thoroughly washed with distilled water to remove any external contaminants that must have been attached to the surface before sampling, and then cut into chips using a stainless kitchen knife and grater, which had already been washed and rinsed with distilled water. Samples were placed on aluminium foil and dried for four days in an opened laboratoryfloor area under normal atmospheric condition. Thereafter, the samples were dried in oven at 87°Cuntil no detectable change in weight was achieved. Eachdriedfood sample was grindedto fine powderusing a Sonix blender (Model: SB-510B). Then, 200 g of each sample were measured into already cleaned cylindrical plastic containers of a uniform size, labelled appropriately to prevent any mix-up and triple sealed for four weeks to allow for attainment of secular equilibrium between parent and daughter nuclidesbefore embarking gamma spectrometric analysis.

### Gamma Spectroscopic Measurement of Activity Concentration

The gamma spectroscopic analysis of the samples was conducted using a low-level 76 mm x 76 mm NaI(TI) gamma detector available at the environmental radioactivity laboratory of the department of Physics and Engineering Physics, Obafemi Awolowo University, Ile-Ife, Nigeria. A cylindrical 10 cm thick Canberra Pb shield was used to enclose the detector to reduce the background radiation. The gamma detector has a resolution of 8% efficiency at energy of 0.662 MeV ($^{137}$Cs) capable of differentiating the gamma-ray energies of the radionuclides of interest in this study. The output of the detector was connected to Canberra series 10 plus Multichannel Analyser (MCA) (Model

No. 1104) through a preamplifier base and a computer with Canberra software analyzer for spectral acquisition and analysis that matches the acquired gamma energies to a library of possible isotopes. International Atomic Energy Agency (IAEA) reference water sample was used for efficiency calibration for the various energy peaks. Each sample was placed on top of the detector and counted for 60,000 seconds. Empty container of same material and geometry with that of the samples was used as background and counted for same duration of time. The background counts and other counts due to Compton scattering of higher peaks were subtracted from the total counts to get the net area under the corresponding photopeaks. The analysis and activity of the parent radionuclides depends on those of the daughter energy peaks of the decay products in equilibrium with their parent radionuclides (Ajayi and Owolabi, 2008; Awodugba and Tchokossa, 2008). Therefore, the gamma-ray peak of 911.1 keV and 583.1 keV of $^{228}$Ac and $^{208}$Tl, respectively were used for the identification of $^{232}$Th activity; that of $^{238}$U was gotten from 1120.3 and 609.3 keV gamma peak of $^{214}$Bi and 351.9 keV peak of $^{214}$Pb, while the single gamma peak of 1460.8 keV was used for $^{40}$K. Based on this and other defined parameters of net counts under, efficiency, gamma intensity,sample mass and counting time, the activity concentration of $^{40}$K, $^{232}$Th and $^{238}$U in each sample was estimated using the following relation (Jibiri et al., 2007).

$$AC(Bq.kg^{-1}) = \frac{C_n}{\varepsilon P_\gamma M_s} \qquad (1)$$

where AC is the activity concentrations of radionuclides in the sample, $C_n$ is the total net count rate under each photopeak, $P_\gamma$ is the absolute transition probability of the specific gamma energy, ε is the efficiency of the detector for the specific gamma energy and $M_s$is the mass of the sample in kilogram (kg).

### Estimation of Radium equivalent activity (Raeq)

In any samples, natural radionuclides are not uniformly distributed. To quantify the uniform activity of the radionuclides as a single quantity, the radium equivalent activity ($Ra_{eq}$) is therefore defined (UNSCEAR, 2000). The premise is supported by the observation that the same gamma dose is produced by 4810 Bq/kg of $^{40}$K, 370 Bq/kg of $^{238}$U, and 259 Bq/kg of $^{232}$Th (UNSCEAR, 2000). Based on this, the $Ra_{eq}$in the food samples was evaluated using the following relation (Beretka and Mathew, 1985; UNSCEAR, 2020).

$$Ra_{eq} = A_u + 1.43A_{Th} + 0.077A_K \quad (2)$$

where $A_K$, $A_{Th}$and $A_u$represent, respectively, the activity concentration of $^{40}$K, $^{232}$Th and$^{238}$U.

### Results and Discussion

Table 1 shows the measured activity concentrations of $^{40}$K, $^{238}$U and $^{232}$Th in the various food samples that were examined. The presented values are given on dry bases of the samples and in the units of Bqkg$^{-1}$ with the analytical uncertainty. It was observed that the activity concentration of $^{40}$K in the samples ranges from 548.74 ± 110.53 Bqkg$^{-1}$ in Lemon Grass to 1095.94 ± 210.91 Bqkg$^{-1}$ in Okro, with mean value of 797.61 ±192.98 Bqkg$^{-1}$. For $^{232}$Th, the values ranged from 21.17 ± 3.59 Bqkg$^{-1}$ in Plantain to 67.26 ± 12.28 Bqkg$^{-1}$ in Cassava, with mean of 40.75 ±17.84Bqkg$^{-1}$ while that of $^{238}$U varied from 25.22 ± 2.47 Bqkg$^{-1}$in Pepper to 42.36 ± 4.15 Bqkg$^{-1}$ in Okro, with mean value of 32.51 ±5.35 Bqkg$^{-1}$. As observed, $^{40}$K exhibited the highest activity concentrations in all the sample, Figure 1 clearly shows this observation. Activity concentration of $^{232}$Th was higher than $^{238}$U in samples of Plantain, Melon, Ogbono and Lemon Grass whereas in

Okro, Pepper, Cassava and Coconut, 238U was higher. In all, the obtained mean concentrations of the radionuclides in the samples decreased in this order, $^{40}K > ^{232}Th > ^{238}U$, with 40K contributing highest percentage (Figure 2) to the total radioactivity content of the sampled food stuffs. The noticed high concentration of $^{40}K$ in the samples may be due to the natural abundance of potassium radionuclide in the earth crust (Nahar et al., 2018) as well as the possible use of potassium enriched fertilizers by farmers during cultivation for greater crop yields (Nahar et al., 2018; Ugbede and Akpolile, 2020). Potassium is a much-needed micro mineral for plant growth and development, therefore it is easily transfer from soil through plant roots which in turn can get accumulated in various plant parts (Ugbede, 2022). Additionally, the result demonstrates that the radioisotope $^{40}K$ is the most prevalent in the agricultural soil where the samples were produced. Potassium is distributed in the various body part and being an essential intracellular cation, it is under homoeostatic regulation (Hassan et al., 2021). For this reason, it does not contribute much to internal radiation doses (Hassan et al., 2021; Ugbede, 2022), thus, the present concentration of 40K in the food samples may not be of much radiological concern. On the other hand, thorium and uranium and their progenies are highly radiotoxic and through the food chain, they can accumulate in critical organs of the body with high radiation doses(Akhter et al., 2007; Nahar et al., 2018; Ahmad et al., 2019).It is to be noted that the transfer ability of the radionuclides from soil to the food chain varies with radionuclides, and also depends the plant species, geological location, physical, chemical, and microbial characteristics of the soil, type of fertilizers used and duration of use, and cultivation techniques (Alsafar et al., 2015; Asaduzzaman et al., 2015). Previous studies carried out in order locations had also reported higher concentration for 40K than the other radionuclides (Venturini and Sordi, 1999; Arogunjo et al., 2005; Shanthi et al., 2010; Avwiri and Agbalagba, 2013; Alsafar et al., 2015; Jayasinghe et al., 2020).

**Table 1: Measured activity concentration ($Bqkg^{-1}$) of natural radionuclides and radium equivalent activity ($Bqkg^{-1}$)in food samples of Sapele**

| Sample | $^{40}K$ | $^{238}U$ | $^{232}Th$ | Radium equivalent activity |
|---|---|---|---|---|
| Okro | 1095.94± 210.91 | 42.36±4.15 | 54.30±9.91 | 204.597 |
| Pepper | 875.34±168.46 | 25.22± 2.47 | 57.92±10.57 | 175.447 |
| Cassava | 785.62±151.19 | 37.21±3.65 | 67.26±12.28 | 193.885 |
| Plantain | 769.84±113.85 | 28.30±3.08 | 21.17±3.59 | 117.851 |
| Coconut | 615.27±118.41 | 32.93±3.23 | 45.72±8.35 | 145.686 |
| Melon | 1025.44±197.35 | 32.93± 3.23 | 31.41 ± 3.67 | 156.806 |
| Ogbono | 664.75± 107.75 | 29.44 ±2.97 | 24.94 ±3.07 | 116.29 |
| Lemon Grass | 548.74 ± 110.53 | 31.70±3.11 | 23.34 ±2.73 | 107.33 |
| Mean | 797.61 ±192.98 | 32.51 ±5.35 | 40.75 ±17.84 | 152.23 ±36.97 |

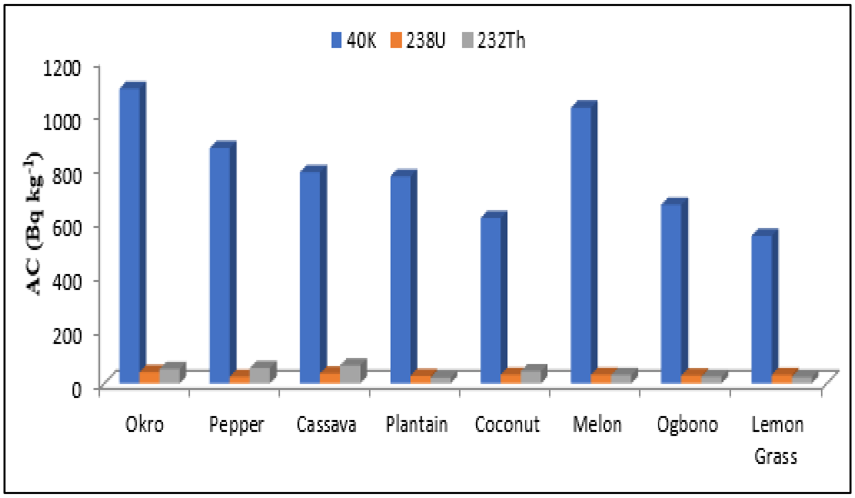


Figure 1: Distribution of natural radionuclides in food samples of Sapele

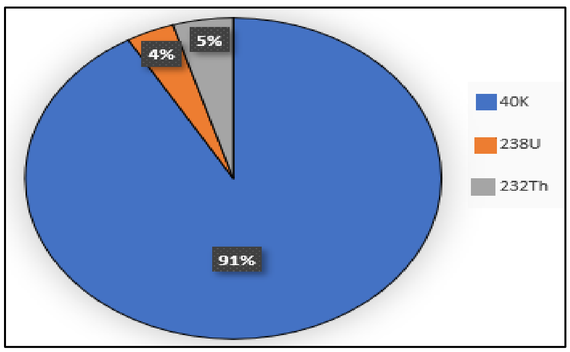


Figure 2: Percentage contribution of natural radionuclides to the total radioactivity of food samples of Sapele

## Conclusion

Natural radionuclides($^{40}$K, $^{238}$U and $^{232}$Th) concentrations in some foodstuffssold in Sapele part of Delta State, Nigeria have been determined. Measured concentrations of the radionuclides show significant values, with 40K having higher value which can be attributed to the natural abundance of potassium radionuclides in the earth crust as well as use of fertilizers to improve crop yields. The obtained data correlated with other similar studies reported in literature. It hoped that the present data will be valuable to policy framework of food agencies and WHO in Nigeriafor the radiological and toxicological food safety monitoring.

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