Journal of Radiation and Nuclear Applications
An International Journal

http://dx.doi.org/10.18576/jrna/100103

Investigation of Radioactivity Levels in Some Selected Imported Canned Foods Consumed in Abuja, Nigeria

Aremu Feyisayo Ibukunoluwa, Ibrahim Umar, Abdullahi Abubakar Mundi, Samson Yusuf Dauda*

Department of Physics, Faculty of Natural and Applied Sciences, Nasarawa State University, Keffi, Nigeria

Received: 2 Oct. 2024, Revised: 22 Nov. 2024, Accepted: 1 Dec. 2024.
Published online: 1 Jan 2025

Abstract: Food is any substance that provides nutritional support to the human body and the biological safety of the food is always taken into account, however contamination with radionuclides is also possible. The objectives of this study were to evaluate the activity concentrations of natural radionuclides (^{238}U, ^{226}Th, and ^{40}K) of some selected imported canned foods commonly consumed in Abuja, Nigeria, and their radiological health hazard using sodium iodide detector. The results obtained showed a mean activity value of 2.43±0.02Bqkg^{-1}, 0.38±0.02Bqkg$^{-1,}$ and 69.74±2.43 Bqkg^{-1} for ^{238}U, ^{226}Th, and ^{40}K respectively. The results also showed that the mean value of radium equivalent activity was 9.17 Bqkg^{-1}, while the values of internal hazard index, absorbed dose rate (DR) and annual effective dose equivalent (AEDE) were 0.03, 4.78 nGyh^{-1}, and 23.45µ Svy^{-1} respectively. The mean values of the Annual Gonadal Effective Dose (AGED) and that of the representative gamma index were 34.37 µSvy^{-1}and 0.07 respectively. The overall values obtained were below the world-permissible values of the United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR). It can be concluded that the canned foods analyzed in this study do not have any significant radiological concerns.

Keywords: Canned and Imported Foods, Radioactivity Concentration, hazard, effective dose.

1 Introduction

Radioactivity occurs when the nuclei of an unstable atom emit particles of ionizing radiation, losing energy in the process. Some radionuclides are naturally occurring, while others are man-made. Radionuclides such as uranium-238, thorium-232, and potassium-40 can enter the body through contaminated food, water, or inhaled air [1-5]. Food is essential for all living organisms supporting life functions such as growth, development, and bodily maintenance, and its consumption represents a major exposure pathway for these radionuclides [6-8]. Most foods are derived primarily from plants (fruits, vegetables, grains, tubers, grains, etc.) and animals [9-12]. Food supplies the body with essential nutrients, including vitamins and minerals. However, it also contains trace amounts of naturally occurring radionuclides and, when ingested, can contribute to an internal radiation dose [13-14]. Human activities, including the use of radionuclides as food preservatives, the nuclear fuel cycle, widespread pesticide use, and radionuclide applications for therapeutic or other purposes, have contributed to increased radioactivity levels in food [15]. By 2024, Nigerian canned

Thefood industry is projected to generate $126.825 million [16].Canned food refers to food that has been processed and sealed in airtight containers to prolong its shelf life. With shifting dietary habits and higher disposable incomes, many individuals are opting for canned foods, which has led to increased demands in the market. In addition, canned food requires less preparation contributing to market growth. The canned food market is also expected to grow in the coming years owing to increased investments and new product launches by major international companies in the country. This study seeks to assess the radioactivity levels of some imported canned food consumed in Nigeria.

Most food manufacturers use a variety of techniques such as irradiation, to stop the activities of enzymes that lead to spoilage in both processed and unprocessed foods. Canned foods generally have a long shelf life and can be transported and stored without requiring special conditions. [17]. However, despite their convenience and nutritional value, canned food may contain radioactive contaminants, which may result from environmental exposure, substandard processing methods, or poor packing [18]. The ingestion of radionuclides through food is a significant contributor to long-term radiation exposure, affecting various organs in the body [19-20]. Assessing the radiological risk levels of canned foods is essential for evaluating their safety and health implications. The study aims to fill the existing knowledge gap regarding

*Corresponding author e-mail: pheyishayor88@gmail.com

radiological hazards associated with imported canned foods consumed in Nigeria to conduct an accurate analysis of the health benefits. Additionally, it will provide a detailed database of radionuclide levels and contribute to establishing regulatory standards for radiation safety in food imports. While previous studies have focused on the radioactivity of common staple foods. This study extends the research by examining imported canned foods, which are now widely consumed across Nigeria.

2 Materials and Methods

2.1 Study Area and Population

Abuja, the Nigeria nation's capital, is in the country's geographic center at latitude 9.4N and longitude 7.29E. It covers an area of about 8,000 square kilometers. The scenic landscape of FCT is made up of gently undulating hills scattered with river valleys, with an average local relief of 50 meters between the hilltops and the valley bottom. With a population of about 6000 000 and a 35% annual growth rate, Abuja continues to be the fastest-growing metropolis in Africa [21]. Other contiguous metropolitan areas bordering Abuja include Mandala, Keffi, Kaduna, and Lokoja. The Nnamdi Azikiwe International Airport serves Abuja Municipality, which also serves as Nigeria's political and administrative hub. Mandala, Keffi, Kaduna, and Lokoja are some additional adjacent metropolises that border Abuja [22]. A total of 20 samples of imported canned food made of different brands were randomly sourced from various shopping malls and local supermarkets within Abuja metropolis, Nigeria. The selected samples include meat, tomato paste, fish, vegetables, grains, etc. The selected canned food Sample No, Brand Name, Sample Code, Sample Type, and Country of Manufacture, are presented in Table 1.

2.2 Method of Sample Preparation

The study was conducted for 6 months between March 2022 to August 2022. As soon as the samples were collected, the dried samples were grounded, sieved, and put into clean plastic jars with a specific geometry (cylindrical) corresponding to the calibration source for gamma activity analysis and sealed with masking tape. The wet samples were placed into the plastic jars and 10 ml of hydrochloric acid was added to each wet sample after which it was left open for 24 hours before sealing to avoid contamination by radioactive particles. The sealed containers were properly labeled and left for at least 28 days to allow short-lived radionuclides (238-U and 232-Th) to achieve secular equilibrium. The samples were subjected to gamma spectrometric analysis at the Centre for Energy Research and Development (CERD), Obafemi Awolowo University, Ille-Ife, Nigeria. A thallium-activated Sodium Iodide detector system measuring 7.62 cm x 7.62 cm was used for the measurement [23].

Table 1.0: Description of samples investigated in this study.

Sample No	Brand name	Sample code	Type	Country of manufacture
1	Costa Sardines in Vegetable oil	001	Sardine	China
2	Estus Sweet Corn	002	Sweet Corn	
3	Maliange Mushrooms	003	Mushrooms	
4	Wintom Tomato Paste	004	Tomato Paste	
5	Spice Supreme Sesame Seeds	005	Sesame Seed	USA
6	Spice Supreme Garlic Powder	006	Garlic	
7	Spice Supreme Ground Cinnamon	007	Ground Cinnamon	
8	Basil Leaves	008	Basil leaves	
9	TRS Brown Mustard Seed	009	Mustard Seed	India
10	Basmati rice	010	Basmati rice	
11	Princes Hot Dogs	011	Hot dogs	Netherlands
12	Batchelors Small Peas	012	Small peas	
13	Heinz Beanz	013	Baked beans	UK
14	Farrow's Giant Marrowfat Peas	014	Marrow Fat Peas	
15	Princes Sardines	015	Sardines in Sunflower oil	
16	Quaker Oats	016	Quaker Oats	
17	Zwan Chicken Luncheon Meat	017	Chicken Luncheon Meat	Holland
18	Napa Flake Tuna Fish	018	Flake Tuna Fish in vegetable oil	Thailand
19	Century Tuna Flakes Fish	019	Tuna flake fish in brine	Philippines
20	Exeter Corned beef	020	Corned beef	Brazil

2.3 Data Analysis

i. Activity Concentration

Activity concentrations of samples are calculated from the net area of a given peak according to the following equation reported by [24-26]:

$$C\left(BqKg^{-1}\right)=\frac{C_n - C_O}{\varepsilon P_y M_s}$$

(1)

where C(Bq/Kg^{-1}) is the activity concentration of the radionuclide in the sample, C_n, is the count rate under the corresponding peak, C_o, is the count rate of background, Ɛ is the detector efficiency at the specific gamma-ray energy, P_y is the probability of gamma emission and Ms is the mass of the sample.

ii. Internal Hazard Index

The hazard index is utilized to calculate the degree of gamma radiation risk connected to the naturally occurring radionuclides in food samples. The internal hazard index is calculated from the equation previously used by [27-28]:

$$H_{in}=\left(\frac{A_U}{185BqKg^{-1}}+\frac{A_{Th}}{259BqKg^{-1}}+\frac{A_K}{4810BqKg^{-1}}\right)\leq 1$$

(2)

where A_U, A_{Th} , and A_K are the soil activity concentrations in Bq·kg^{-1} of ^{226}Ra, ^{232}Th, and ^{40}K respectively. The H_{in} value must not exceed 1 to be accepted as negligible.

iii. Radium Equivalent Index

When different mixtures of the radionuclides Ra, Th, and K in a material emit gamma rays, it is referred to as having a radium equivalent activity (Ra). The radium equivalent (Bq/kg) for each food sample was calculated as [27-28]:

$$Ra_{eq}\left(BqKg^{-1}\right)=A_{Ra}+1.43A_{Th}+0.077A_K$$

(3)

Where A_u, $A_{Th,}$ and A_K are the activity concentration in (Bqkg^{-1}) of ^{226}Ra, ^{232}Th, and ^{40}K, respectively in the food samples

iv. Absorbed Dose Rate

The absorbed dose rate due to direct exposure to the radionuclides from the samples was calculated as explained by UNSCEAR [29]:

$$D\left(nGyh^{-1}\right)=\left(R_u * A_u\right)+\left(R_{Th} * A_{Th}\right)+\left(R_K * A_K\right) \qquad (4)$$

where D is the abso1rbed dose rate of gamma radiation in (nGy/h). R_u, R_{Th}, and R_K are the conversion factors ^{238}U, ^{232}Th, and ^{40}K respectively which equals 0.4551, 0.5835, and 0.0429 (nGyhr^{-1}/ Bqkg^{-1}) respectively. A_u, A_{Th}, and A_K are the activity concentrations in (Bq/kg) for ^{238}U, ^{232}Th, and ^{40}K respectively.

v. Annual Effective Dose Equivalent (AEDE)

By using a dose conversion factor of 0.7 SvGy-1 and an occupancy factor of 0.8 to the absorbed dose rate, the annual effective dose equivalent was calculated as explained by UNSCEAR [29]:

$$AEDE(\mu Svy^{-1}) = D(nGyh^{-1}) * 8760h * 0.7SvGy^{-1} * 0.8 * 10^{-3} \qquad (5)$$

vi. Annual Gonadal Equivalent Dose (AGED)

Due to their radiation sensitivity, the gonads, bone marrow, and bone surface cells are regarded as organs of interest (UNSCEAR, 2000). As AGED levels rise, the bone marrow is known to be affected, which destroys red blood cells and leads to the deadly blood cancer known as leukemia. The AGED was computed following the work of Avwiri [21] as:

$$AGED\left(\mu Svy^{-1}\right)=3.09A_u+4.18A_{Th}+0.314A_K$$

(6)

where, A_u, A_{Th}, and A_K are the radioactivity concentration

of 238U, 232Th, and 40K in the samples

i. Gamma Index

To estimate the gamma radiation hazard associated with the natural radionuclide in specific investigated samples, the gamma index Iγ was calculated following the work of Avwiri [30]:

$$I_\gamma=\frac{A_U}{150}+\frac{A_{Th}}{100}+\frac{A_K}{1500}=\leq 1 \qquad (7)$$

Where, A_u, A_{Th}, and A_K are the radioactivity concentration of ^{238}U, ^{232}Th, and ^{40}K in the samples.

3 Results and Discussion

The activity concentration of radionuclides ^{238}U, ^{226}Th, and ^{40}K in the canned food samples calculated using equation (1) is presented in Table (2). The result obtained from the radioactivity concentration in Bqkg^{-1} ranged from 0.28±0.01 to 7.73±0.03 with a mean of 2.43±0.02 for ^{238}U and 0.09±0.01 to 1.29±0.04 with a mean of 0.38±0.02 for ^{226}Th and 9.59±0.92 to 235.65±4.57 with a mean of activity concentration of 69.74±2.43 for ^{40}K respectively. It was observed that the ^{40}K had the highest activity concentration while ^{226}Th had the least activity concentration. Evaluation of the three naturally occurring radionuclides in the canned food samples using the UNSCEAR [29] permissible limits showed, that activity concentrations of ^{238}U, ^{226}Th, and ^{40}K in all the samples are below the permissible limits.

Table 2: Activity concentration in Bqkg^{-1} of 238U, 232Th, and 40K in canned food sample.

Sample No.	Sample Code	Activity Concentration		
		^{238}U	^{232}Th	^{40}K
1	001	3.75±0.02	0.16±0.02	152.66±3.68
2	002	0.39±0.02	0.16±0.02	9.59±0.92
3	003	0.35±0.01	0.13±0.01	23.79±1.45
4	004	6.28±0.02	0.21±0.02	41.89±1.93
5	005	0.32±0.02	0.15±0.02	21.83±1.39
6	006	0.33±0.02	0.16±0.02	23.43±1.44
7	007	0.31±0.02	0.15±0.02	17.57±1.25
8	008	0.37±0.02	0.16±0.02	25.38±1.50
9	009	4.3±0.02	0.39±0.02	164.02±3.82
10	010	1.29±0.02	0.17±0.02	56.8±2.25
11	011	0.43±0.02	0.15±0.02	11.89±1.03
12	012	7.03±0.04	1.02±0.04	200.59±4.22
13	013	5.66±0.03	0.62±0.03	137.13±3.49
14	014	0.41±0.02	0.16±0.02	80.59±2.67
15	015	7.73±0.03	0.59±0.03	235.65±4.57
16	016	3.37±0.04	1.29±0.04	116.98±3.22
17	017	0.45±0.01	0.13±0.01	74.73±2.58
18	018	5.08±0.04	0.98±0.04	115.29±3.20
19	019	0.28±0.01	0.09±0.01	18.28±1.27
20	020	0.38±0.03	0.70±0.03	82.72±2.71

Table 3: Comparison of activity concentration in Bqkg^{-1} of different canned foods with those of similar food items from other countries.

Food	Country	Radioactivity Concentration (Bqkg^{-1})			References
		^{238}U	^{232}Th	^{40}K	
Basil Garlic	Najaf, Iraq	BLD BLD	4.83±0.11 3.55±0.09	236.39±1.43 154.64±1.09	[31]
GARLIC	Portharcourt, Nigeria	BLD	12.79±1.6	714.71±63	[32]
Mushroom Sweet Corn Green Peas Tomatoes Paste	Baghdad, Iraq	0.33 B.D.L. 0.18 0.21	B.D.L. 0.1093 B.D.L. 0.21	180.93 229.24 222.91 227.65	[33]

Mushroom	Tehran, Iran	-	0.033±0.006	55±6.00	[24]
Canned Tuna Sardines	Kingdom of Saudi Arabia	1.5 ± 0.8 0.37 ± 0.3	1.0 ± 0.60 1.2 ± 0.30	192.3 ± 14.6 219.8 ± 15.8	[35]
Canned rice	Hilla City	2.787±0.408	6.058±0.58	77.671±38.54	[36]
Sweet Corn Garlic Mushroom Basil Basmati Rice Tomatoes Paste Small Peas Canned Sardines Canned Tuna	Abuja, Nigeria	0.39±0.02 0.33±0.02 0.35±0.01 0.37±0.02 1.29±0.02 6.28±0.02 7.03±0.04 5.74±0.03 2.68±0.03	0.39±0.02 0.16±0.02 0.13±0.01 0.16±0.02 0.17±0.02 0.21±0.02 1.02±0.04 0.36±0.03 0.54±0.03	0.39±0.02 23.43±1.44 23.79±1.45 25.38±1.50 56.8±2.25 41.89±1.93 200.59±4.22 194.16±4.13 66.79±2.24	Present Study

3.1 Radiation Hazard Parameters

Table 4.0: Radiation hazards evaluated in samples.

Sample	**D ($nGyh^{-1}$)**	**Raeq ($Bqkg^{-1}$)**	**(H_{in})**	**AGED (μSvy^{-1})**	**Iγ**	**AEDE (μSvy^{-1})**
Baked Beans	8.35	15.73	0.05	60.19	0.13	40.96
Basil Leaf	0.68	1.36	0.00	4.89	0.01	3.35
Basmatic Rice	1.17	2.22	0.01	8.47	0.02	5.74
CenturyTuna Fish	1.25	2.36	0.01	9.05	0.02	6.13
Corned Beef	9.22	17.49	0.06	66.42	0.14	45.23
Costal Sardine	1.26	2.37	0.01	9.09	0.02	6.16
Farrow GiantPeas	4.78	9.81	0.04	33.44	0.07	23.44
Flake Tuna Fish	0.79	1.56	0.01	5.69	0.01	3.89
Garlic Powder	8.82	17.11	0.06	63.14	0.14	43.27
Cinnamon	3.74	6.84	0.02	27.24	0.06	18.33
Mushroom	3.49	6.39	0.02	25.40	0.05	17.10
Mustard Seed	13.97	26.72	0.09	100.35	0.21	68.54
Prince Hot Dog	7.83	15.36	0.06	55.99	0.12	38.41
Prince Sardine	0.96	1.82	0.01	6.98	0.01	4.73
Sesame Seed	12.40	23.93	0.08	88.97	0.19	60.83
Small Pea	4.13	7.75	0.02	30.07	0.06	20.26
Sweet Corn	7.30	14.22	0.05	52.54	0.11	35.83
Tomato Paste	0.98	1.88	0.01	7.10	0.02	4.82
White Oats	1.35	2.55	0.01	9.78	0.02	6.63
Swan Chicken	3.12	5.91	0.02	22.53	0.05	15.32

The analysis in this study focuses on radiological hazard indices, carried out in six (6) parts: internal radiation index, radium equivalent index, absorbed dose rate, annual effective dose equivalent, annual gonadal equivalent dose, and representative gamma index. The results of the analysis are presented in Table 3.0 and Figures 1 and 2. The analysis of the internal radiation hazard index in Table 4.0, shows that the value ranged from 0.00 to 0.09 with a mean value of 0.03. The values obtained were below the unity value recommended as the standard permissible value which denotes that the samples are safe for consumption.

The result of the estimated radium equivalent dose shows a value range from 1.56 $Bqkg^{-1}$ to 26.72 $Bqkg^{-1}$ with a mean value of 9.17 $Bqkg^{-1}$. The values obtained are far below the international acceptable limit of 370 $Bqkg^{-1}$ for Raeq and, therefore comply with the radium equivalent standard for radioactivity concentration.

The overall absorbed dose rate for the samples due to ^{238}U, ^{226}Th, and ^{40}K ranged from 0.68 $nGyh^{-1}$ to 13.67 $nGyh^{-1}$ with a mean value of 4.78 $nGyh^{-1}$ which is less than the world's permissible value of 80 $nGyh^{-1}$**,** hence posing no hazards. The estimated annual effective dose equivalent obtained for the samples ranged from 3.35 μSvy^{-1} to 68.54 μSvy^{-1} with a mean activity concentration of 23.45μSvy^{-1}. It is observed that the values of the annual effective dose equivalent of the samples are lower than the world's average values of 450 μSvy^{-1}**.** This shows that the samples are radiologically safe for consumption.

The result of the AGED ranged from 4.89μSvy^{-1} to 100.35μSvy^{-1} with a mean activity concentration of 34.37μSvy^{-1}. The values obtained are below the world's permissible values of 300μSvy^{-1} [29]. Thus, consumption of any of the samples may not cause any radiation health risk.
The result of the gamma index I_γ ranged from 0.01 to 0.19 with a mean of 0.07. The results obtained are below the average world value of unity and hence pose no radiation hazard.

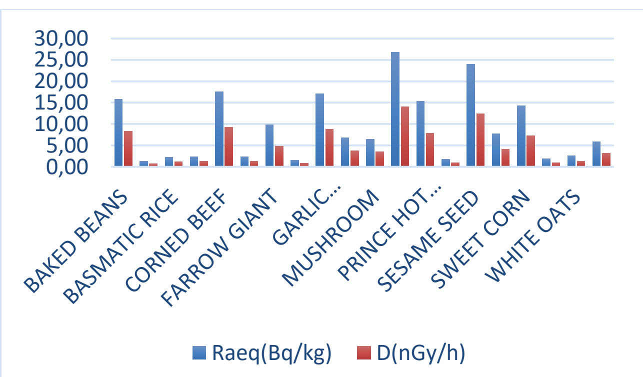

Fig.1: Radium equivalent activity (Ra_{eq}) ranges and the absorbed dose rate of gamma radiation for the samples.

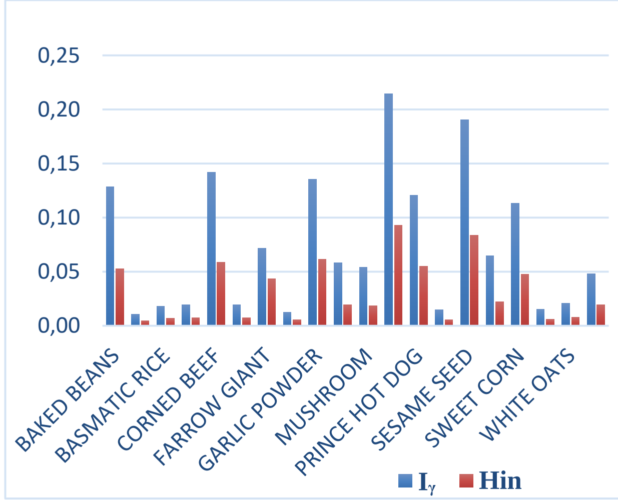

Fig.2: Gamma representative index I_γ and internal hazard index H_{in} for the samples.

The results obtained in this study are in line with the findings of [37] who determined the activity concentration of walnuts collected from different markets in the city of Sulaimanya, Kurdistan Region of Iraq, and obtained a radium equivalent index of 16.6606 $Bqkg^{-1}$ using high-purity germanium detector. This study is also similar to the findings of other researchers such as [36] who determined the natural radioactivity of canned rice samples in Hilla City and obtained a radium equivalent index of 17.380 $Bq.kg^{-1}$, using a sodium iodide detector, and [38] who determined the activity concentration of natural radionuclides in marine croaker fish from two coastal areas of Nigeria (Lagos and Portharcourt and obtained a radium equivalent of 267.21$BqKg^{-1}$ and 618.56 Bq kg^{-1}respectively using thallium activated sodium iodide detector.

The results from this study, however, were not in line with the findings of [39] who determined the radioactivity and radiological hazard of different food items collected from local markets in Bangladeshi and obtained a radium equivalent index of 113.89 Bqkg-1 using high-purity germanium detector and [40] who determine the concentrations of natural radionuclides (^{238}U, ^{40}K, and ^{232}Th) in selected food commonly consumed in Enugu State, Nigeria, using high-purity germanium detector.

4 Conclusions

Generally, the results show trends that are low for most of the radiological hazard indices estimated in the study as Recommended by the UNSCEAR thresholds. It can be concluded that the implemented technique presented good results when compared with other literature data. Also, it can be concluded that imported canned foods in Abuja analyzed are radiologically safe for consumption because their radioactivity levels are lower than the maximum permitted levels. Hence this study serves as a baseline for radiological data on imported canned foods for future investigation that could inform quality assurance and control on the analysis of natural radionuclides in canned food samples.

Acknowledgment

The authors acknowledge the staff of the Centre for Energy Research Development of the Obafemi Awolowo University, Ile-Ife, where the samples were analyzed.

References

[1] K.M.A Mohsin. Estimating Radioactivity in various types of milk using NaI (TI) Detector. *Journal University of Kerbala*, 15 (1), 1 – 5, (2017).

[2] Sherif A Taalab, Meshari Al Meshari, Yasser Alzamil, Ahmad Abanomy, Amjad R Alyahyawi, Waheed H Mohamed, Atef El-Taher., Radiological and ecological hazards evaluation of episyenite used as building materials. Journal of Radioanalytical and Nuclear Chemistry 332 (6), 2057-2075.(2023).

[3] A. El-Taher, A Ashry, A Ene, M Almeshari, HMH Zakaly., Determination of phosphate rock mines signatures using XRF and ICP-MS elemental analysis techniques: Radionuclides, oxides, rare earth and trace elements. Rom. Rep. Phys 75 (2), 701.(2023).

[4] A. El-Taher, EES Massoud, MAE Abdel-Rahman., Assessment of natural radioactivity levels and radiological hazard indices in soil samples collected from the central region of Saudi Arabia. Radiochemistry 64 (3), 399-408.(2022).

[5] HA Madkour, AM Mansour, MA Sebak, A Badawai, A. El-Taher., Observation of changes in sediment nature by environmental impacts of Abu-Makhadeg Area, Red Sea, Egypt. Journal of Environmental Science and Technology. 12(2) 55-64.(2019).

[6] A. A. Mundi, I. Umar and M. M. Idris, Contamination and Pollution Risk Assessment of Heavy Metals in Rice Samples (Oryza sativa) from Nasarawa West, Nigeria. Asian Journal of Advanced Research and Reports, 3(4), 1-8, (2019).

[7] E.E.J. Iweala, J.A.O. Olugbuyiro, B.M. Durodola, D.R. Fubara-Manuel and A.O. Okoli, Metal contamination of foods and drinks consumed in Ota, Nigeria. Research Journal of Environmental Toxicology, 8(1), 92 – 97, (2014).

[8] A. El-Taher, WM Badawy, AEM Khater, HA Madkour., Distribution patterns of natural radionuclides and rare earth elements in marine sediments from the Red Sea, Egypt. Applied Radiation and Isotopes 151, 171-181.(2019).

[9] S.C. Izah, E.R. Aseiba and L.A. Orutugu, Microbial quality of polythene packaged sliced fruits sold in major markets of Yenagoa Metropolis, Nigeria. Point Journal of Botanical Microbiology Research, 1 (1), 30 – 36, (2015).

[10] A. El-Taher, WM Badawy, AEM Khater, HA Madkour., Distribution patterns of natural radionuclides and rare earth elements in marine sediments from the Red Sea, Egypt. Applied Radiation and Isotopes 151, 171-181.(2019).

[11] A. El-Taher, MAK Abdelhalim., Elemental analysis of phosphate fertilizer consumed in Saudi Arabia. Life Science Journal 10 (4), 701-708.(2013).

[12] R Elsaman, MAA Omer, EMM Seleem, A. El-Taher., Natural radioactivity levels and radiological hazards in soil samples around Abu Karqas Sugar Factory. Journal of Environmental Science and Technology, 2018, Vol. 11, No. 1, 28-38.(2018).

[13] HA Madkour, AM Mansour, AEHN Ahmed, A. El-Taher., Environmental texture and geochemistry of the sediments of a subtropical mangrove ecosystem and surrounding areas, Red Sea Coast, Egypt. Arabian Journal of Geosciences 7, 3427-3440.(2014).

[14] F. S. Olise, O.K. Owoade, and H.B. Olaniyi, Radiological indices of technologically enhanced naturally occurring radionuclide: a PIXE approach. Radial Prot., 31(2), 64 – 255, (2011).

[15] F. R. Jannatul, B. Projit, E. Aleya and A. Habibul, Study of Natural and Artificial Radioactivity in some Food Grains. SCIREA Journal of Food, 1(21), 32 – 50, (2016).

[16] Research and Market (2019). The Nigerian Canned Food Market Forecast 2019-2024. 62 Pages, ID 4895730. December, 2019. Knowledge Sourcing Intelligence LLP. https://www.researchandmarkets.com/reports/4895730/nigeria-canned-food-market-forecasts-from-2019

[17] D. Dave and A. E. Ghaly, Meat spoilage mechanisms and preservation techniques: a critical review," American Journal of Agricultural and Biological Science, 6 (1), 486 – 510, (2011).

[18] A. Buculei, S. Amariei, M.. Oroian, G. Gutt and L.B. A. Gaceu, Metals migration between product and metallic package in canned meat, LWT-Food Science and Technology, 58(2), 364 – 374, (2014).

[19] P. McDonald, D. Jackson, D.R.P. Leonard, and K. McKay, An assessment of 210Pb and 210Po terrestrial foodstuffs from regions of potential technological enhancement in England and Wales. Journal of Environmental Radiation 43(1), 15 -29, (1999).

[20] G. Fernandez, I.M. Rodriquez, G.V. Castro, G. Carrazana and R.N. Martinez, Radiological surveillance of foods and drinking water in the Cuban Republic, Proceeding of the 11th Conference of the International Radiation Protection Association (IRPA), Madrid, Spain, 4 (1), 13 – 23, (2004).

[21] I. Enitan, A. Enitan, J. Odiyo and M. Alhassan, Human health risk assessment of trace metals in surface water due to leachate from the municipal dump-site by pollution index:

a case study from Ndawuse River, Abuja, Nigeria. Open Chem 16 (1),214–227, (2018).

[22] C. E. Igibah and J.A. Tanko, Assessment of urban groundwater quality using Piper trilinear and multivariate techniques: a case study in the Abuja, North-central, Nigeria.Environmental Systems Research Journal, 8 (1-14), (2019).

[23] S.O. Alayande, A. Omosalewa, G. Ezeh, A. Ofudje, G. Seglo and I. Tubosun, Evaluation of Radiation Emission and Elemental Analysis in e-waste dumpsites, FUW Trends in Science & Technology Journal, 1 (1), 267- 271, (2016).

[24] J. B. Olomo, M.K. Akinloye and F.A. Balogun, Distribution of Gamma Emitting-natural Radionuclides in soils and water around Nuclear Research establishments, Ile-Ife, Nigeria. Nuclear Instrument Methods Physics Research, 353(1), 553 – 557, (1994)..

[25] M. K. Akinloye and J.B. Olomo, The Measurement of the Natural Radioactivity in some tubers cultivated in Farmlands within the Obafemi Awolowo University Ile-Ife, Nigeria. Nigeria Journal of Physics, 12(1), 60 – 63, (2000).

[26] N.N. Jibiri, I.P. Farai, and S.K. Alausa, Estimation of Annual Effective Dose due to Natural Radioactive Elements in Ingestion of Foodstuffs in Tin Mining Area of Jos-Plateau, Nigeria. Journal of Environmental Radioactivity, 94 (2), 31- 40, (2007).

[27] A. H. Taqi, A. M. Shaker and A. A. Battawy, Natural Radioactivity Assessment in Soil Samples from Kirkuk City of Iraq Using HPGe Detector. International Journal of Radiation Research, 16, 455-463, (2018).

[28] E.O. Agbalagba and R.A. Onoja, Evaluation of Natural Radioactivity in Soil sediments and Water samples of Niger Delta (Biseni) flood plain lakes, Nigeria. Journal of Environmental Radiation, 102 (1), 667 – 671, (2011).

[29] UNSCEAR. (2000). Sources and effects of ionizing radiation. United Nations Scientific Committee on the Effects of Atomic Radiation UNSCEAR 2000 report to the general assembly, with scientific annexes (UNSCEAR 2000 Report, Vol. I). New York, NY. doi:10.1097/00004032-199907000-00007.

[30] G. O. Avwiri, Determination of radionuclide levels in soil and water around cement companies in Port Harcourt. Journal of Applied Sciences and Environmental Management, 9(3), 26 -29, (2005).

[31] A. Abojassim, H. Hady. & Z. Mohammed, Natural radioactivity levels in some vegetables and fruits commonly used in Najaf Governorate, Iraq. Journal of Bioenergy and Food Science, 3(3), 113-123, (2016).

[32] C. P. Ononugbo, G. O. Avwiri and S. O. Ikhuiwu, Estimation of Natural Radioactivity Levels in Some Food Spices Commonly Used in Nigeria and Its Radiological Risks. Journal of Scientific Research & Reports., 16(3), 1-9, (2017).

[33] A. O. Abdul-Jabbar and H. A. Asia, Contamination and Radionuclides Concentration in Imported Canned Foodstuffs in Baghdad Markets. International Letters of Natural Sciences, 48,49-49, (2015).

[34] A. Abbasi. and V. Bashiry. Estimation of cancer risk due to radiation exposure for some daily consumption of foods. Journal of Cancer Research and Therapeutics, 16(8), 64 – 67, (2020).

[35] D A. Aloraini, G. A. Alharshan, A.H Almuqrin, H. Al-Ghamdi and K.M. El-Azony, Evaluation of The Activity of Gamma-Emitting Natural Radionuclides in Seafood and Estimation Of The Annual Effective Dose For Different Age Groups In KSA. Radiation Protection Dosimetry, 178(2), 193–200, (2018).

[36] H.A. Alyaa and K.M. Mohsin, Study of Natural Radioactivity (238U, 232TH, 40K) for Canned Rice Samples in Local Markets in Hilla City. Plant Archives 18 (2), 1847 – 1850, (2018).

[37] M. R. A. Jamal, O. A. Kamal, M. H. Adil, R. M. Awara, and N. H. Amir, Measurement of natural radioactivity concentrations in walnut collected from different markets in Sulaimanya city-Kurdistan region-Iraq. Materials Science and Engineering, 871, (2020).

[38] M. Adeleye, B. Musa, O. Oyebanjo, S. Gbenu and S.O. Alayande, Activity Concentration of Natural Radionuclides and Assessment of The Associated Radiological Hazards in The Marine Croaker (Pseudotolitus Typus) Fish from Two Coastal Areas of Nigeria. Science World Journal, 15(2), (2020).

[39] S. Afrin, S. Mahfuz, P. Shikha and R. Mizanur, Assessment of Radioactivity and Radiological Hazard of Different Food Items Collected from Local Market in Bangladesh. Journal of Bangladesh Academy of Science, 43(2), 141-148, (2020).

[40] H.U. Chiegwu, F.O. Odoh, D.C. Ogwuanyi, T. Adejoh and C.C. Ohagwu, Natural Radionuclides in Food items commonly consumed in Enugu State, Nigeria. The Tropical Journal of Health Sciences, 27(1), 8 – 20, (2020).