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COMPARATIVE STUDY OF RADIOLOGICAL HEALTH RISKS IN FLUTED PUMPKIN LEAVES CULTIVATED WITH AND WITHOUT INORGANIC FERTILIZERS

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Abstract: This study investigates the activity concentrations of naturally occurring radionuclides in fluted pumpkin leaves and the corresponding farm soils, assessing the associated Annual Effective Dose (AED) and Excess Lifetime Cancer Risk (ELCR) for crops cultivated with and without inorganic fertilizers. Using a high-purity Germanium (HPGe) detector, radionuclide levels were measured in samples from various locations. For fluted pumpkin grown with inorganic fertilizers, AED values ranged from 0.398 to 0.707 $\mu Sv \cdot yr^{-1}$, with a mean of 0.517 $\mu Sv \cdot yr^{-1}$—below the ICRP recommended limit of 1 $\mu Sv \cdot yr^{-1}$. ELCR values for these samples ranged from 0.001053 to 0.001944, all below the 0.01 safety threshold. In contrast, fluted pumpkin cultivated without inorganic fertilizers showed higher AED values ranging from 0.400 to 1.088 $\mu Sv \cdot yr^{-1}$ (mean 0.677 $\mu Sv \cdot yr^{-1}$), with one site exceeding the recommended dose limit. Corresponding ELCR values ranged from 0.0011 to 0.001866, still below the recommended limit but generally higher than those for fertilized crops. These results suggest that the use of inorganic fertilizers may influence radionuclide uptake and reduce radiation exposure risks in fluted pumpkin cultivation. Overall, both cultivation methods pose low radiological health risks, though attention should be given to locations exceeding AED guidelines.

Keywords: Radionuclides, Fluted Pumpkin, Activity Concentration, Inorganic Fertilizers, Cancer Risk

1. INTRODUCTION

Radionuclides are atoms with excess nuclear energy, making it unstable. Radioactive decay is usually random at the level of single atoms and it is impossible to predict when one particular atom will decay [2]. For a collection of atoms of a one element, the decay rate, and thus the half-life ($t_{1/2}$) for that collection can be calculated from their measured decay constants. Naturally occurring radionuclides of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K have significant contributions in the ingestion dose and are present in the biotic system of plants, animals, soil, water and air. Distribution of radionuclides in different parts of the plant depends on the chemical characteristics and several parameters of the plants and soil [11]. Inhalation and ingestion are the main pathways through which natural radionuclides enter into the human body. Dietary pathways become contaminated with radioactive materials from naturally enhanced radionuclides and man-made applications during routine operation, accidents, and migration of radionuclides from radioactive waste disposal repositories into the biosphere [13].

Contamination of the food chain occurs as a result of direct deposition of radionuclides on the plant leaves, root uptake from contaminated soil or water, and animals ingesting contaminated plants, soil or water. Ingestion of food crops grown in contaminated soil can be a major source of human exposure to radionuclides since it can lead to internal radiation doses. Considerable efforts are being made by authors in many parts of the world to measure the activity of radionuclides in the food chain, the radiological burden and the estimated soil–plant transfer of radionuclides Uranium, radium, thorium, potassium and their decay products are among the most important radionuclides and they can be easily transferred from soil to plants through roots [17]. Phosphate rocks which are starting material for production of fertilizers contain high levels of uranium, thorium and other heavy metals. Due to reduction or loss of soil fertility in most Nigerian soils, inorganic fertilizers are used to boost crop yield. This consequently has a bearing on the chemical and radionuclide composition of the crops grown on such soil [3].

The extensive use of fertilizers can increase the amount of radionuclides in soil, plants, groundwater and consequential ingestion by humans through exposure routes such as drinking water and the food chain. Once deposited in bone tissue ^{226}Ra has a high potential for causing biological damage because of the continuous irradiation of the human skeleton. Since radionuclides are naturally available in soil and can also be enhanced by man through activities such as successive application of phosphate fertilizers and pesticides, mining and milling operations, burning of fossil fuels amongst others, it is therefore necessary to know the uptake of natural radionuclides by the plant from the soil.

2. MATERIALS AND METHOD

2.1. Study Area

The study area covered selected locations within Awka, the capital of Anambra State, where Nnamdi Azikiwe University is situated. Anambra State lies in the southeastern part of Nigeria and belongs to the South-East Geopolitical Zone. It is located between latitudes 5°38′N and 6°47′N, and longitudes 6°36′E and 7°21′E. The State is bordered on the east by Enugu State, on the west by Delta State, on the north by Kogi State, and on the south by Imo State. The Department of Botany, Nnamdi Azikiwe University, Awka, served as the focal point of the study, with sampling carried out within the University environment and adjoining areas of Awka metropolis.

2.2. Sample Collection and Preparation

Some factors considered in selection of sample sites include: farmlands where fluted pumpkin (*Telfairia occidentalis)* were highly cultivated, farmlands where only organic fertilizers were used and farmlands where a combination of both organic and inorganic fertilizers were used. The type of fertilizers used were also noted, whether organic or inorganic fertilizers. The amount of fertilizer applied was also noted. A total of 18 fluted pumpkin leaf samples and their corresponding soil samples were collected. The farms were divided into evenly spaced sites with a distance of 20m between each site for larger coverage of the farm according to [8]. At each sampling location, the soil surface was cleared of stones, pebbles, vegetation and roots. Soil samples were collected around the root area of the sampled plants. Soil samples of about 2.0kg (wet weight) were collected

from each position with a shovel, and at a depth of about 15cm to 20cm. Samples of the corresponding fluted pumpkin leaves were also collected. Each sample was put in a separate polythene bag and labeled carefully.
The fluted pumpkin leaf samples collected were thoroughly washed with tap water, and then washed in distilled water to remove surface sand and debris [14]. The samples were then cut into small pieces and exposed to ambient air in a dust-free environment before being dried to a constant weight for 48 hours in a monitored oven maintained at 80°C in the laboratory. The samples were then ground to powdery form, sieved and then weighed. The weight of the dry plant samples varied between 220g and 300g.
For soil sample preparation, the method used by [7] was adopted. The soil samples were also exposed to ambient air in a dust-free environment, dried, pulverized and then sieved. The weight of each soil sample was about 500g to 600g. Both the fluted pumpkin leaf samples and soil samples were then packed in properly sealed air tight polythene bags and labeled with appropriate sample codes. Thereafter, the samples were taken to National Institute of Radiation Protection and Research, Ibadan, for analysis.

2.3. Method for Sample Analysis

The prepared fluted pumpkin leaf samples and soil samples were taken to National Institute of Radiation Protection and Research in University of Ibadan for analysis. The activity concentration of naturally occurring radionuclides in edible plants and their corresponding soil samples were measured using a High Purity Germanium (HPGe) Detector. The HPGe used was manufactured by Canberra, model GC 8023 with serial number 9744. For each soil sample, 500g of soil was measured and poured into a 500ml Marinelli beaker while 200g was used for each plant sample. The beaker was covered with the beaker lid and sealed properly to ensure that there was no space for escape of any radioactive gas. It was left for 28 days to attain secular equilibrium before being moved to the gamma analysis room for counting. Each sample was counted for 18,000seconds. Peak analysis was then done with Genie 2000 software. Based on Equation 2.1 Activity concentration was determined by the earlier efficiency calibration done. The radionuclides considered were ^{238}U, ^{232}Th, ^{226}Ra and ^{40}K. Using the excel data sheet the values for AED and ELCR were calculated based on Equations 2.2 and 2.3.

2.4. Activity Concentration in Samples

The activity concentration (AC) in unit of Bq kg^{-1}, for radionuclides with detected photo peak at energy E, was calculated from Equation 2.1 given by [12].

$$C = \frac{N_t}{TP_y EM} \qquad 2.1$$

Where C is the activity concentration of radionuclides in Bq kg^{-1}, N_t is the net count under corresponding photo peak, T is the counting time in seconds, P_r gamma intensity of specific gamma-ray, £ absolute efficiency, and M mass of sample in (kg), respectively. World reference value for AC in soil for ^{238}U, ^{226}Ra, ^{232}Th, and ^{40}K are 35 Bq/kg, 35 Bq/kg, 30 Bq/kg and 400 Bq/kg respectively. AC for leafy vegetables are 20 Bq/kg for ^{238}U and 15 Bq/kg for ^{232}Th [15].

2.5. Radiological Health Risk Assessment of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K in soil and Fluted Pumpkin Samples

Health Risk Assessment was carried out in terms of the Annual Effective dose (AED) and Excess Lifetime Cancer Risk (ELCR) due to consumption of the sampled plants.

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Annual Effective Dose (AED) due to consumption of food crops (Ingestion Dose):

The Annual effective dose received by the public from the consumption of the vegetable samples was estimated using Equation 2.2 [1].

$$Total\ AED = \sum A_i \times DCf_i \times C_r \qquad 2.2$$

A_i (Bq/kg) is the specific activity of radionuclide, DCf_i (mSv/Bq) is the dose conversion factor of radionuclide i, C_r (kg.yr^{-1}) is the annual consumption rate of the samples. The DCf values are 2.8 $\times 10^{-7}$; 4.5 x 10^{-8}; 2.3$\times 10^{-7}$ and 6.2$\times 10^{-9}$Sv/Bq for ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K respectively [11].

Excess lifetime cancer risk (ELCR)

The excess lifetime cancer risk (ELCR) associated with the consumption of the radionuclides in the fluted pumpkin leaf samples were calculated using Equation 2.3 [10]. This was to determine the potential carcinogenic effects of the long-term consumption of these samples,

$$ELCR = AED \times \quad \times RF\ DL \qquad 2.3$$

Where AED is the annual effective dose, DL is the duration of life (55 years) and RF is the fatal cancer risk factor which is 0.05 for the public [11]. The ELCR recommended world mean value is 0.0029 [11].

3. RESULTS AND DISCUSSION

3.1. Radionuclide Activity Concentration in Fluted Pumpkin (*Telfairia occidentalis)* and soil Samples

Tables 3.1to 3.4 presents the values of the activity concentration of radionuclides in fluted pumpkin cultivated with and without inorganic fertilizers and the soil in which the samples where cultivated in the study areas. Tables 3.1 to 3.4 show the distribution of the mean activity concentration in Bq/Kg of the fluted pumpkin samples cultivated with and without inorganic fertilizers and the soil the fluted pumpkin samples were cultivated.

Table 3.1: Activity concentration of ^{40}K, ^{226}Ra, ^{238}U and ^{232}Th in Bq/Kg for fluted Pumpkin leaf samples cultivated with inorganic fertilizers from the study area.

LGA	Sample codes	^{238}U	^{226}Ra	^{232}Th	^{90}K
Abak	F_1	43.16±3.75	6.91±1.63	11.43±0.94	1152.35±60.95
	F_2	BDL	10.42±0.89	14.50±1.04	1694.24±89.01
	F_3	16.50±1.99	8.85±0.61	9.02±0.61	1127.59±59.64
	F_4	18.54±2.85	14.72±1.94	22.15±1.70	1409.51±74.57
	Mean	19.55±2.15	10.23±1.27	14.28±1.07	1345.97±71.04
EtimEkpo	F_5	19.57±2.32	8.47±1.09	23.76±1.74	1605.07±84.89
	F_6	9.08±1.51	6.90±0.81	28.04±1.56	1363.62±72.12
	F_7	15.11±1.91	13.08±0.95	42.81±2.38	1363.62±72.12
	Mean	14.59±1.91	9.48±0.95	31.54±1.89	1454.05±76.90
OrukAnam	F_8	47.69±4.18	13.60±1.36	10.02±1.17	1260.88±66.69
	F_9	86.96±5.93	21.28±1.38	44.30±2.46	1361.34±72.00
	Mean	67.33±4.91	17.44±1.37	31.16±1.82	1311.11±69.35
Overall Mean		43.50±3.02	16.02±1.18	29.11±1.51	1324.92±72.62

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Table 3.2: Activity concentration of ^{40}K, ^{226}Ra, ^{238}U and ^{232}Th in Bq/Kg for soil where fluted Pumpkin was cultivated with inorganic fertilizers from the study area.

LGA	Sample codes	^{238}U	^{226}Ra	^{232}Th	^{90}K
Abak	S_1	51.29±2.79	20.69±1.67	32.30±1.71	41.25±2.21
	S_2	35.71±2.23	21.99±1.14	33.20±1.17	16.55±0.96
	S_3	49.21±2.77	20.00±1.04	27.11±1.45	27.11±1.45
	S_4	57.49±3.12	22.16±1.14	36.97±1.98	27.59±1.51
EtimEkpo	S_5	67.98±3.64	21.57±1.12	31.99±1.70	16.83±1.01
	S_6	51.96±2.88	19.73±1.02	31.38±1.68	25.61±1.41
	S_7	59.15±3.18	22.21±1.15	35.36±1.86	6.98±0.15
OrukAnam	S_8	53.45±2.98	28.58±1.47	56.68±2.98	58.99±3.14
	S_9	43.26±2.53	17.45±0.96	23.83±1.27	8.23±0.58
Overall Mean		57.52±2.90	24.81±1.19	39.48±1.76	28.82±1.42

Table 3.3: Activity concentration of ^{40}K, ^{226}Ra, ^{238}U and ^{232}Th in Bq/Kg for fluted Pumpkin leaf samples cultivated without inorganic fertilizers from the study area.

LGA	Sample codes	^{238}U	^{226}Ra	^{232}Th	^{90}K
EssienUdim	F10	50.47±4.08	28.23±2.03	24.10±4.08	1293.38±68.41
	F11	73.13±5.84	25.94±1.48	65.32±3.59	1499.98±79.33
	F12	50.47±4.23	21.67±1.24	49.27±2.71	1227.26±64.91
	F13	BDL	15.43±0.98	36.16±2.02	805.28±42.89
	Mean	43.52±4.62	22.82±1.43	43.71±3.10	1206.48±63.89
IkotEkpene	F14	BDL	9.48±1.36	4.81±0.84	1582.93±83.72
	F15	25.27±2.23	7.17±0.83	27.94±1.59	1286.69±68.05
	Mean	12.64±2.23	8.33±1.10	16.38±1.22	1434.81±75.89
Ikono	F16	BDL	14.46±1.36	25.97±1.52	1538.42±81.37
OrukAnam	F17	18.17±2.21	13.15±1.03	17.10±1.17	1444.44±76.40
Uyo	F18	BDL	8.67±1.08	11.35±0.74	1245.91±65.70
Overall Mean		43.50±2.03	16.02±1.27	29.11±1.58	1324.92±70.00

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Table 3.4: Activity concentration of ^{40}K, ^{226}Ra, ^{238}U and ^{232}Th in Bq/Kg for soil where fluted pumpkin samples was cultivated without inorganic fertilizers from the study area.

LGA	Sample codes	^{238}U	^{226}Ra	^{232}Th	^{90}K
EssienUdim	S10	62.29±3.36	28.19±1.45	47.08±2.48	42.41±2.27
	S11	69.70±3.76	22.76±1.18	44.13±2.35	43.08±2.32
	S12	59.63±3.26	31.32±1.61	55.44±2.92	46.002.46
	S13	65.92±3.52	27.08±1.40	37.49±1.99	23.50±1.32
IkotEkpene	S_{14}	47.84±2.71	28.04±1.45	36.88±1.95	35.12±1.89
	S15	46.81±2.68	19.17±0.99	31.57±1.68	17.83±1.03
Ikono	S_{16}	73.79±3.87	25.61±1.32	44.73±2.36	39.22±2.09
OrukAnam	S_{17}	43.26±2.28	17.45±0.96	23.83±1.27	8.23±0.58
Uyo	S_{18}	48.41±2.67	23.67±1.22	34.14±1.80	4.02±0.36
	Overall Mean	57.52±3.15	24.81±1.29	39.48±2.09	28.82±1.59

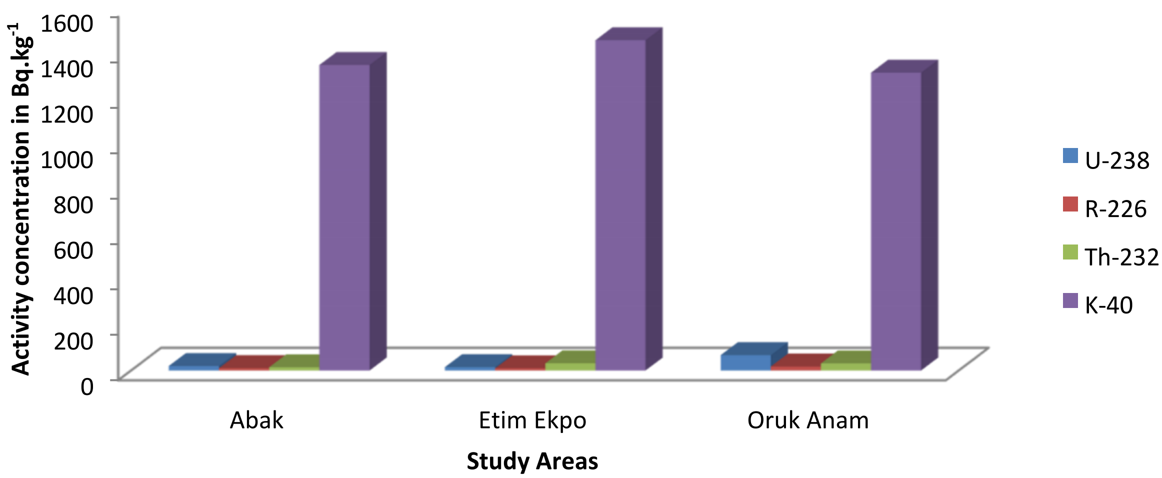

Figure 3.1: Distribution of the mean activity concentration in Bq/Kg of the fluted Pumpkin leaf samples cultivated with inorganic fertilizers from the study Area

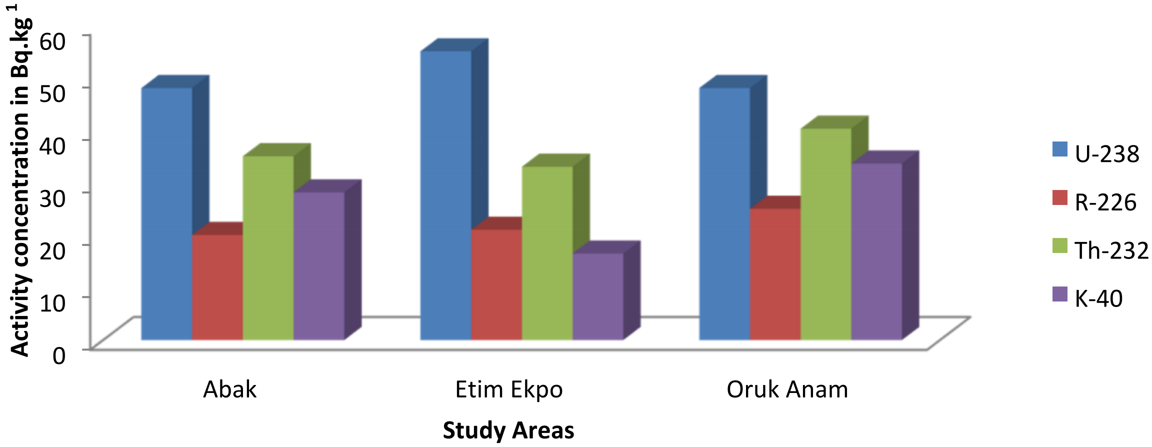

Figure 3.2: Distribution of the mean activity concentration in Bq/Kg of the soil where Fluted pumpkin samples was cultivated with inorganic fertilizers from the study area

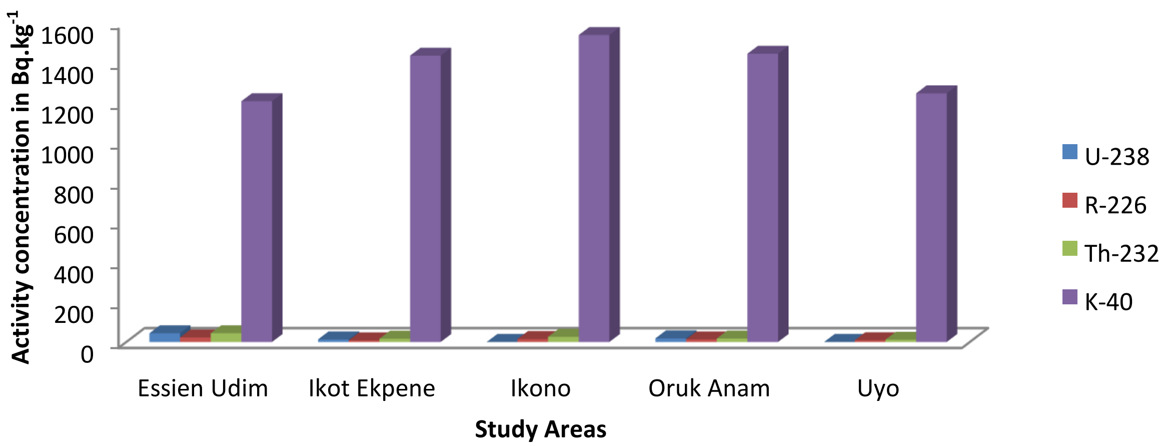

Figure 3.3: Distribution of the mean activity concentration in Bq/Kg of fluted Pumpkin leaf samples cultivated without inorganic fertilizers from the study area

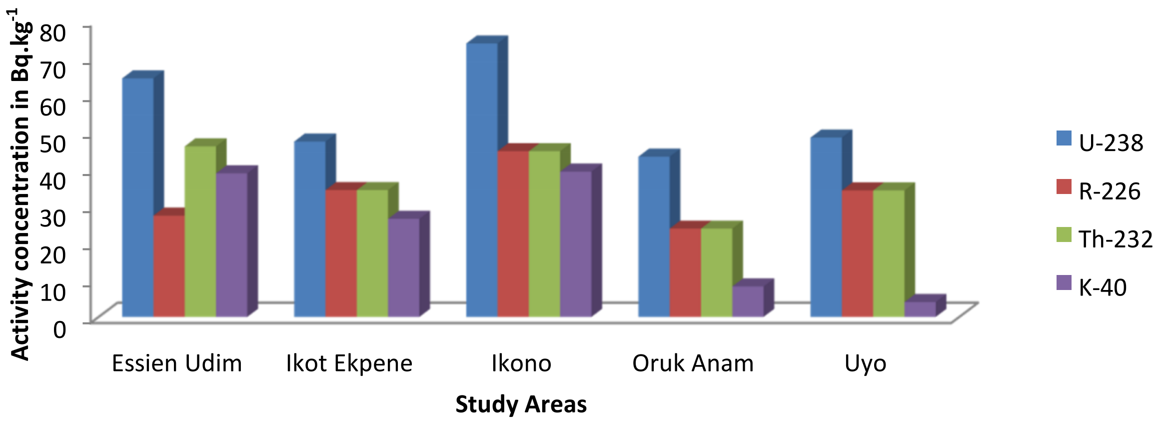

Figure 3.4: Distribution of the mean activity concentration in Bq/Kg of the soil where Fluted pumpkin was cultivated without inorganic fertilizers from the study area

3.2 Health Risk Assessment of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K in the fluted pumpkin Samples

Table 3.5 presents the average annual consumption rates of the fluted pumpkin samples from the study areas. The results of Health Risk Assessment of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K in the fluted pumpkin samples are presented in Tables 3.6 and 3.7.

Table 3.5: Average annual consumption rates of fluted pumpkin samples from the study area

Samples	**Daily Consumption (g)**	**Frequency per week**	**F (frequency/7)**	**Annual Rate (kg.yr^{-1})**
Fluted Pumpkin	120	5	0.71	31.20

Table 3.6: Estimated values of AED and ELCR for Fluted pumpkin leaf samples cultivated with inorganic fertilizers from the study area.

LGA	**Sample**	**AED**	**ELCR**	**codes (µSv.yr^{-1})**
Abak		F_1	0.398	0.001095
		F_2	0.426	0.001172
		F_3	0.524	0.001441
		F_4	0.383	0.001053
EtimEkpo		F_5	0.586	0.001612
		F_6	0.582	0.001601
		F_7	0.544	0.001496
OrukAnam		F_8	0.707	0.001944
		F_9	0.501	0.001378
		Mean	0.517	0.001421

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Table 3.7: Estimated values of AED and ELCR for fluted pumpkin leaf samples cultivated without in organic fertilizers from the study area.

LGA	Sample ELCR	AED	codes ($\mu Sv.yr^{-1}$)
EssienUdim	F10	0.889	0.002445
	F11	0.741	0.002038
	F12	1.088	0.002992
	F13	0.851	0.002340
IkotEkpene	F14	0.425	0.001196
	F15	0.548	0.001507
Ikono	F16	0.612	0.001683
OrukAnam	F17	0.543	0.001493
Uyo	F18	0.400	0.001100
	Mean	0.677	0.001866

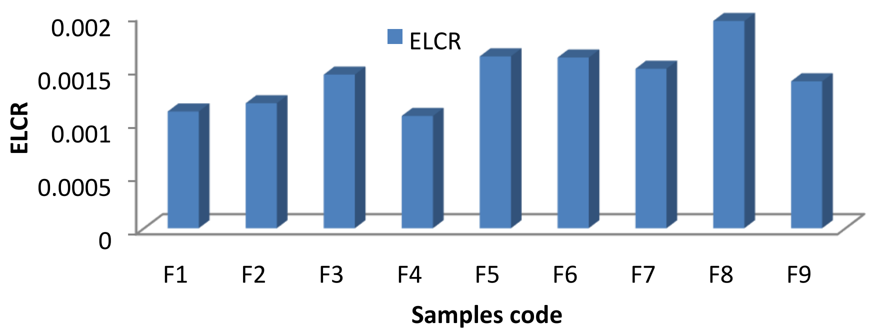

Figure 3.5: Distribution of the excessive life time cancer (ELCR) risk in fluted pumpkin leaf samples Cultivated with inorganic fertilizers from the study area.

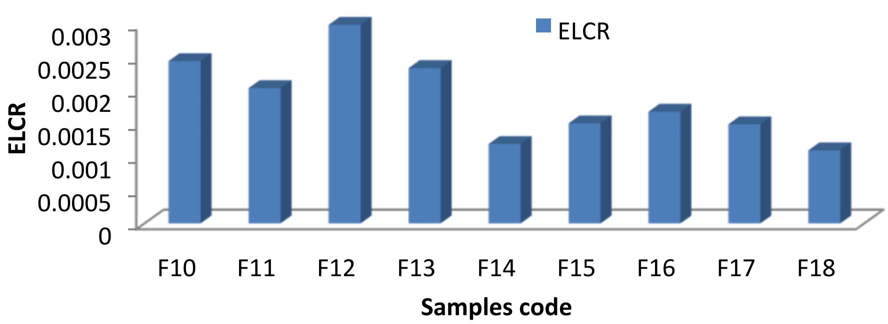

Figure 3.6: Distribution of the excess life time cancer (ELCR) risk in fluted pumpkin leaf samples Cultivated without inorganic fertilizers from the study area.

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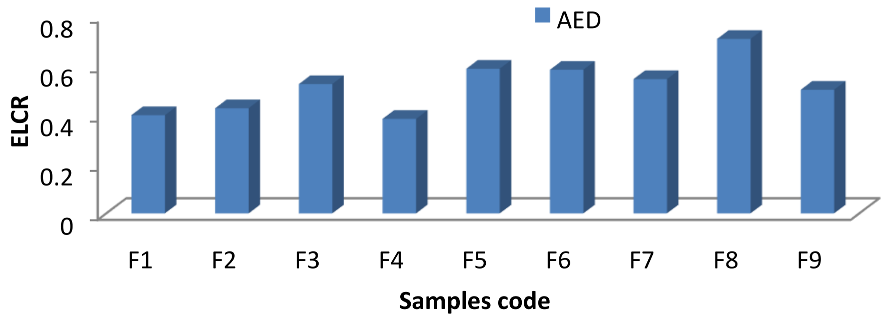

Figure 3.7: Distribution of the Annual Effective Dose (AED) in the fluted pumpkin leaf samples Cultivated with inorganic fertilizers from the study area.

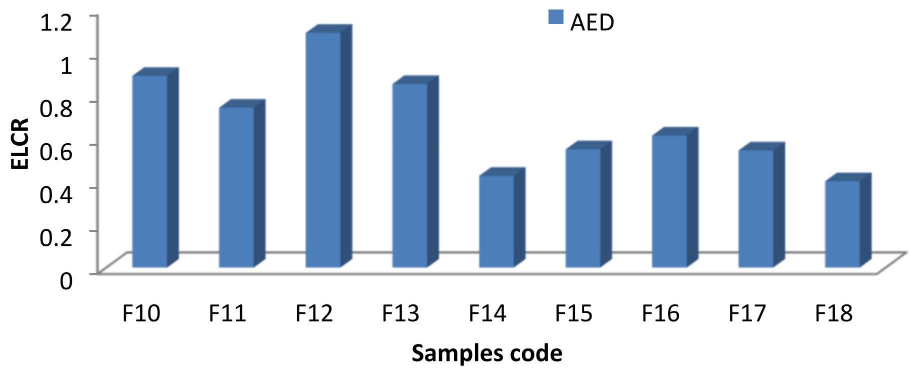

Figure 3.8: Distribution of the Annual Effective Dose (AED) in the fluted pumpkin leaf samples Cultivated without inorganic fertilizers from the study area.

3.3 DISCUSSION

For fluted pumpkin cultivated with inorganic fertilizer, the activity concentration of ^{238}U ranges from BDL to 43.16±3.75 Bq/Kg, 9.08±1.51 Bq/Kg and 47.69±4.18 Bq/Kg for Abak, Etim Ekpo and Oruk Anam respectively. The overall mean for ^{238}U in the study areas is 43.50±3.02 Bq/Kg. for ^{226}R, the activity concentration ranges from 6.90±0.81 Bq/Kg to 14.72±1.94 Bq/Kg with a mean of 16.02±1.18 Bq/Kg. the activity concentration for ^{232}Th also ranges from 9.02±0.61 Bq/Kg to 44.30±2.46 Bq/Kg for all the locations in the study areas. ^{40}K has the highest value of activity concentration for all the study areas and ranges from 1127.59±59.64 to 1694.24±89.04 Bq/Kg. In all the study areas, Oruk Anam has the highest concentration for ^{238}U, ^{226}R and ^{232}Th while Abak has the highest concentration for ^{40}K and lowest for ^{238}U.

In the soil where the fluted pumpkin was cultivated with inorganic fertilizer, concentrations of ^{238}U, ^{226}R, ^{232}Th and ^{40}K ranges from 35.71±2.23 to 67.19±3.64 Bq/Kg, 17.45±0.96 to 28.58±1.47 Bq/Kg, 23.83±1.27 to 36.97±1.98 Bq/Kg and 8.23±0.58 to 58.99±3.14 Bq/Kg respectively. It is observed that the activity concentration of ^{40}K in the fluted pumpkin leaves is higher than that of the soil where the plant is cultivated. This is because a lot of the radionuclide has been transferred to the fluted pumpkin leaves through the roots, stems and even the atmosphere.

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For fluted pumpkin cultivated without inorganic fertilizers, the activity concentration of ^{238}U ranges from BDL to 73.13±5.84 Bq/Kg, for ^{226}R, it ranges from 4.81±0.84 to 28.23±2.03 Bq/Kg, for ^{232}Th, it ranges from4.81±0.84 to 65.32±3.59 Bq/Kg and for ^{40}K, it ranges from 805.21±42.89 to 1582.93±83.72 Bq/Kg. Essien Udim has the lowest activity concentration for ^{40}K while Ikot Ikpene has the highest for ^{40}K. The highest activity concentration for ^{238}U was found in Essien Udim. The highest in ^{226}R and ^{232}Th were also found in Essien Udim. It is observed that the activity concentration of ^{40}K and ^{238}U for fluted pumpkin cultivated with inorganic fertilizers is higher than that cultivated without inorganic fertilizers. But the reverse is the case for ^{226}R and ^{232}Th. For soil where the fluted pumpkin is cultivated without inorganic fertilizers, the mean activity concentration for all the radionuclies ranges from 24.81±1.19 Bq/Kg (^{226}R) to 27.52±2.90 Bq/Kg (^{238}U). For fluted pumpkin leaves cultivated with inorganic fertilizer, the AED due to the consumption of this vegetable ranges from 0.398 $\mu Sv.yr^{-1}$ to 0.707 $\mu Sv.yr^{-1}$ with a mean value of 0.517. The values of AED for all the locations were below the recommended limit of 1 $\mu Sv.yr^{-1}$ as recommended by ICRP. This shows that the level of contamination of the food chain is low and this suggests that consumption of the fluted pumpkin in this area might not pose a high potential hazard to its consumers. The excess life time cancer risk (ELCR) obtained for all the samples in the different locations, ranges from 0.001053 to 0.001944 with a mean of 0.001421. The values obtained for the ELCR in all the locations were lower than the recommended limit of 0.0029 [11]. This shows that intake of the fluted pumpkin cultivated in these areas will not have any significance health risk on the populace.

For fluted pumpkin cultivated without inorganic fertilizers, the AED ranges from 0.400 $\mu Sv.yr^{-1}$ to 1.088 $\mu Sv.yr^{-1}$ with a mean of 0.677. The value of AED obtained in F_{12} (1.088 $\mu Sv.yr^{-1}$) is higher than the recommended limit of 1 $\mu Sv.yr^{-1}$. The values of AED obtained in the fluted pumpkin cultivated without inorganic fertilizers, are higher than the values obtained for fluted pumpkin cultivated with inorganic fertilizers. This is due to the large deposit of the radionuclides in the soil where the fluted pumpkin was cultivated.It was noted that farmers who cultivated with inorganic fertilizer also used organic fertilizer such as poultry manure at some point but in recommended and controlled proportions. While those who cultivated without inorganic fertilizer used only organic fertilizer mainly poultry manure but in uncontrolled proportions. This may also have some effects on the amounts of radionuclides in present in soil and plant of the study area in each case. The ELCR values obtained in all the locations for the fluted pumpkin cultivated without inorganic fertilizers, ranges from 0.0011 $\mu Sv.yr^{-1}$ to 0.001866 $\mu Sv.yr^{-1}$. The values of ELCR are below the recommended limit. It was observed that the fluted pumpkin cultivated without inorganic fertilizers has higher values of ELCR compared to those cultivated with inorganic fertilizers.

4. CONCLUSION

For fluted pumpkin cultivated with inorganic fertilizer, ^{40}K has the highest number of activity concentration for all the study areas and ranges from 1127.59±59.64 to 1694.24±89.04 Bq/Kg. The activity concentration of ^{40}K in the fluted pumpkin is observed to be higher than that of the soil where the fluted pumpkin is cultivated. This is because a lot of the radionuclide has been transferred to the fluted pumpkin leaves through the aerial parts of the plant. The activity concentration of ^{40}K and ^{238}U for fluted pumpkin cultivated with inorganic fertilizers is higher than for that cultivated without inorganic fertilizers. But the reverse is the case for ^{226}R and ^{232}Th. The values of AED obtained in the fluted pumpkin cultivated without inorganic fertilizers, are higher than the values

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obtained for fluted pumpkin cultivated with inorganic fertilizers. This may due to the large deposit of the radionuclides in the soil where the fluted pumpkin was cultivated. It could also be due to methods of fertilizer application or quantity applied be it organic or inorganic fertilizer. The values of ELCR in all the locations are below the recommended limit.

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