

## Estimation of Radiological Health Risk in Fluted Pumpkin Leaf Samples Cultivated with and Without Inorganic Fertilizer

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### Abstract

Activity concentration of radionuclides present in soil and plants is a very useful parameter in accessing the level of radioactive contamination in farmlands and in plants cultivated in such farmlands. This work is aimed at assessing the Annual Effective Dose (AED) and Excess Lifetime Cancer Risk (ELCR) associated with fluted pumpkin leaf samples cultivated with and without inorganic fertilizers. In this work, the activity concentration of naturally occurring radionuclides in the fluted pumpkin and the farm soil were measured using high purity Germanium (HPGe) detector. For fluted pumpkin cultivated with inorganic fertilizer, the Annual Effective Dose AED ranges from  $0.398 \mu\text{Sv.yr}^{-1}$  to  $0.707 \mu\text{Sv.yr}^{-1}$  with a mean value of  $0.517$ . The values of AED for all the locations were below the recommended limit of  $1 \mu\text{Sv.yr}^{-1}$  as recommended by ICRP. 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  $0.01$ . For fluted pumpkin cultivated without inorganic fertilizers, the AED ranges from  $0.400 \mu\text{Sv.yr}^{-1}$  to  $1.088 \mu\text{Sv.yr}^{-1}$  with a mean of  $0.677$ . The value of AED obtained in  $F_{12}$  ( $1.088 \mu\text{Sv.yr}^{-1}$ ) is higher than the recommended limit of  $1 \mu\text{Sv.yr}^{-1}$ . 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. The ELCR values obtained in all locations for fluted pumpkin cultivated without inorganic fertilizers, ranges from  $0.0011 \mu\text{Sv.yr}^{-1}$  to  $0.001866 \mu\text{Sv.yr}^{-1}$ . The values of ELCR are below the recommended limit. However it was observed that the fluted pumpkin cultivated without inorganic fertilizers has higher values of ELCR compared to those cultivated with inorganic fertilizers.

**Keywords:** Radionuclides, Fluted pumpkin, Activity Concentration, Fertilizer, Cancer risk.

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## 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  $^{238}\text{U}$ ,  $^{226}\text{Ra}$ ,  $^{232}\text{Th}$  and  $^{40}\text{K}$  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  $^{226}\text{Ra}$  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 Local Government Areas (LGA) of Akwa Ibom State. Akwa Ibom state is located in the southern coastal part of Nigeria and is within the South-South Geopolitical Zone. It lies between latitudes 4°32'N and 5°33'N, and longitudes 7°25'E and 8°25'E. The State is bordered on the east by Cross River State, on the west by Rivers State and Abia State, and on the south by the Atlantic Ocean and the southernmost tip of Cross River State. The Local Government Areas considered for sampling were Abak, Etim Ekpo, Oruk Anam, Essien Udim, Ikot Ekpene, Ikono and Uyo.

### 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  $^{238}\text{U}$ ,  $^{232}\text{Th}$ ,  $^{226}\text{Ra}$  and  $^{40}\text{K}$ . 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  $\text{Bq kg}^{-1}$ , for radionuclides with detected photo peak at energy E, was calculated from Equation 2.1 given by [12].

$$C = \frac{N_t}{TP_r \epsilon M} \quad 2.1$$

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

### 2.5 Radiological Health Risk Assessment of $^{238}\text{U}$ , $^{226}\text{Ra}$ , $^{232}\text{Th}$ and $^{40}\text{K}$ 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.

#### 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].

$$\text{Total AED} = \sum A_i \times DCf_i \times C_r \quad 2.2$$

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

$$\text{ELCR} = \text{AED} \times \text{RF} \times \text{DL} \quad 2.3$$

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 3.1 to 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 were 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 <sup>40</sup>K, <sup>226</sup>Ra, <sup>238</sup>U and <sup>232</sup>Th in Bq/Kg for fluted Pumpkin leaf samples cultivated with inorganic fertilizers from the study area.**

LGA	Sample codes	<sup>238</sup> U	<sup>226</sup> Ra	<sup>232</sup> Th	<sup>90</sup> K
Abak	F <sub>1</sub>	43.16±3.75	6.91±1.63	11.43±0.94	1152.35±60.95
	F <sub>2</sub>	BDL	10.42±0.89	14.50±1.04	1694.24±89.01
	F <sub>3</sub>	16.50±1.99	8.85±0.61	9.02±0.61	1127.59±59.64
	F <sub>4</sub>	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 <sub>5</sub>	19.57±2.32	8.47±1.09	23.76±1.74	1605.07±84.89
	F <sub>6</sub>	9.08±1.51	6.90±0.81	28.04±1.56	1363.62±72.12
	F <sub>7</sub>	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 <sub>8</sub>	47.69±4.18	13.60±1.36	10.02±1.17	1260.88±66.69
	F <sub>9</sub>	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

**BDL= Below Detection Limit**

**Table 3.2: Activity concentration of <sup>40</sup>K, <sup>226</sup>Ra, <sup>238</sup>U and <sup>232</sup>Th in Bq/Kg for soil where**

**fluted Pumpkin was cultivated with inorganic fertilizers from the study area.**

LGA	Sample codes	<sup>238</sup> U	<sup>226</sup> Ra	<sup>232</sup> Th	<sup>90</sup> K
Abak	S <sub>1</sub>	51.29±2.79	20.69±1.67	32.30±1.71	41.25±2.21
	S <sub>2</sub>	35.71±2.23	21.99±1.14	33.20±1.17	16.55±0.96
	S <sub>3</sub>	49.21±2.77	20.00±1.04	27.11±1.45	27.11±1.45
	S <sub>4</sub>	57.49±3.12	22.16±1.14	36.97±1.98	27.59±1.51
EtimEkpo	S <sub>5</sub>	67.98±3.64	21.57±1.12	31.99±1.70	16.83±1.01
	S <sub>6</sub>	51.96±2.88	19.73±1.02	31.38±1.68	25.61±1.41
	S <sub>7</sub>	59.15±3.18	22.21±1.15	35.36±1.86	6.98±0.15
OrukAnam	S <sub>8</sub>	53.45±2.98	28.58±1.47	56.68±2.98	58.99±3.14
	S <sub>9</sub>	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

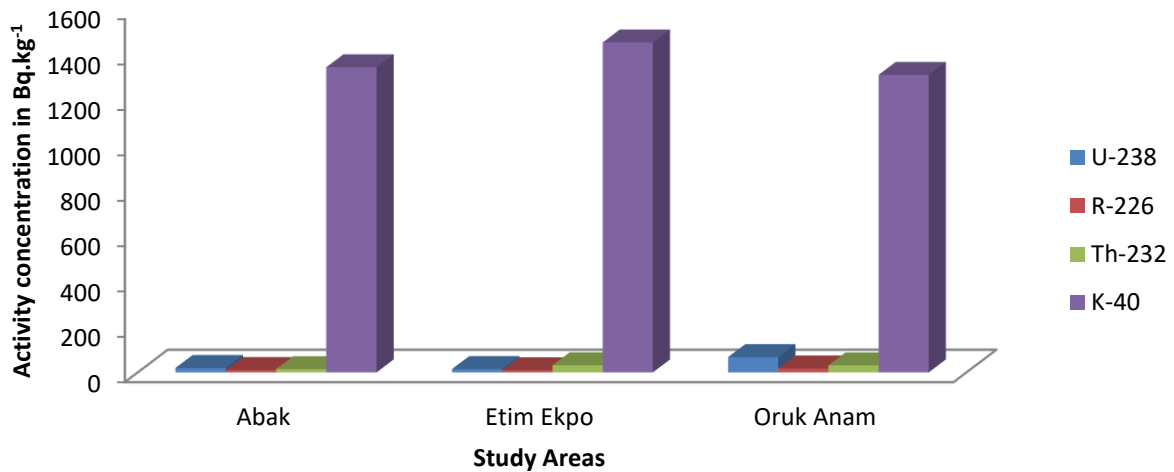
**Table 3.3: Activity concentration of <sup>40</sup>K, <sup>226</sup>Ra, <sup>238</sup>U and <sup>232</sup>Th in Bq/Kg for fluted Pumpkin leaf samples cultivated without inorganic fertilizers from the study area.**

LGA	Sample codes	<sup>238</sup> U	<sup>226</sup> Ra	<sup>232</sup> Th	<sup>90</sup> K
EssienUdim	F <sub>10</sub>	50.47±4.08	28.23±2.03	24.10±4.08	1293.38±68.41
	F <sub>11</sub>	73.13±5.84	25.94±1.48	65.32±3.59	1499.98±79.33
	F <sub>12</sub>	50.47±4.23	21.67±1.24	49.27±2.71	1227.26±64.91
	F <sub>13</sub>	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	F <sub>14</sub>	BDL	9.48±1.36	4.81±0.84	1582.93±83.72
	F <sub>15</sub>	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	F <sub>16</sub>	BDL	14.46±1.36	25.97±1.52	1538.42±81.37
OrukAnam	F <sub>17</sub>	18.17±2.21	13.15±1.03	17.10±1.17	1444.44±76.40
Uyo	F <sub>18</sub>	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

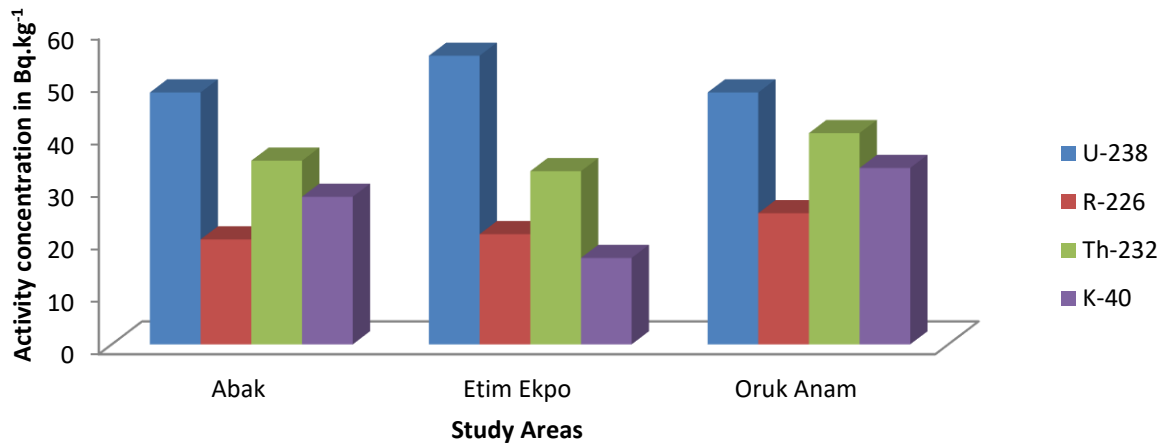
**Table 3.4: Activity concentration of <sup>40</sup>K, <sup>226</sup>Ra, <sup>238</sup>U and <sup>232</sup>Th in Bq/Kg for soil where**

**fluted pumpkin samples was cultivated without inorganic fertilizers from the study area.**

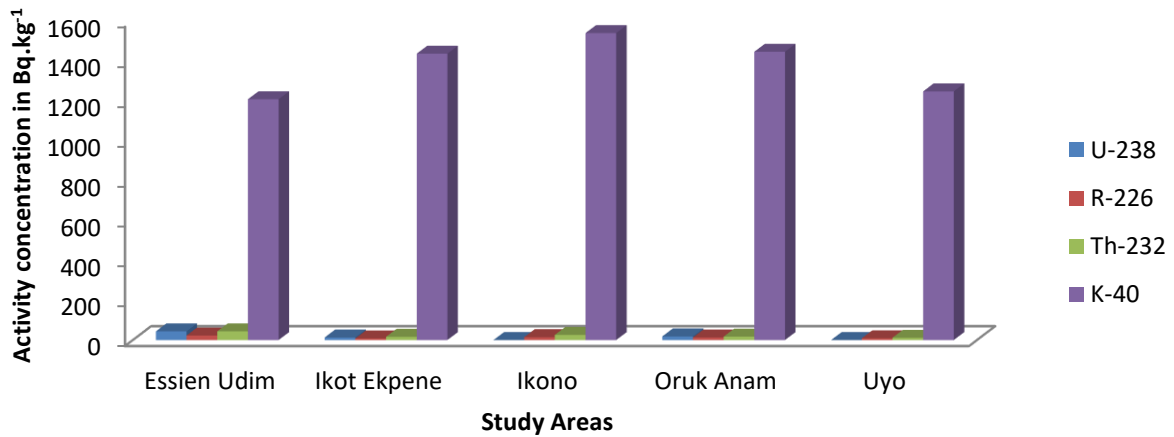
LGA	Sample codes	<sup>238</sup> U	<sup>226</sup> Ra	<sup>232</sup> Th	<sup>90</sup> K
EssienUdim	S <sub>10</sub>	62.29±3.36	28.19±1.45	47.08±2.48	42.41±2.27
	S <sub>11</sub>	69.70±3.76	22.76±1.18	44.13±2.35	43.08±2.32
	S <sub>12</sub>	59.63±3.26	31.32±1.61	55.44±2.92	46.00±2.46
	S <sub>13</sub>	65.92±3.52	27.08±1.40	37.49±1.99	23.50±1.32
IkotEkpene	S <sub>14</sub>	47.84±2.71	28.04±1.45	36.88±1.95	35.12±1.89
	S <sub>15</sub>	46.81±2.68	19.17±0.99	31.57±1.68	17.83±1.03
Ikono	S <sub>16</sub>	73.79±3.87	25.61±1.32	44.73±2.36	39.22±2.09
OrukAnam	S <sub>17</sub>	43.26±2.28	17.45±0.96	23.83±1.27	8.23±0.58
Uyo	S <sub>18</sub>	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**

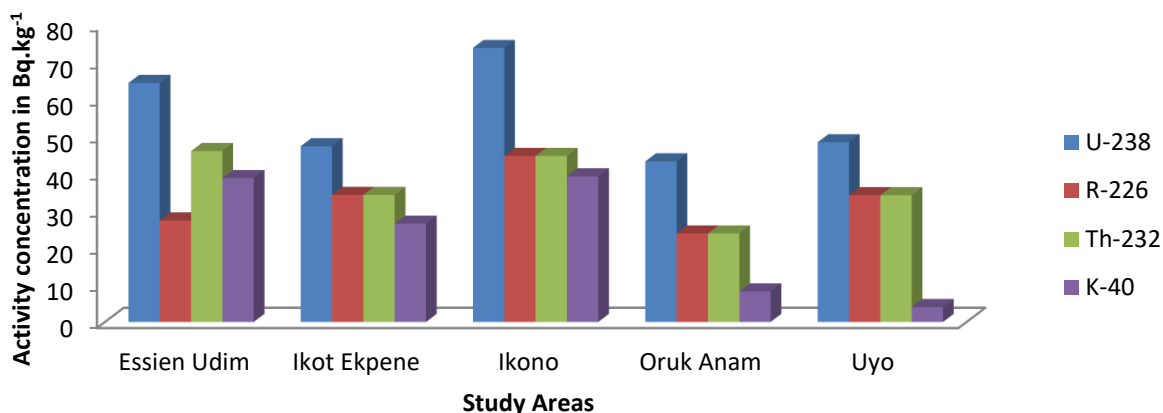


**Figure 3.2:** Distribution of the mean activity concentration in Bq/Kg of the soil where Fluted pumpkin samples was cultivated with inorganic fertilizers from the study area



**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 <sup>238</sup>U, <sup>226</sup>Ra, <sup>232</sup>Th and <sup>40</sup>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 <sup>238</sup>U, <sup>226</sup>Ra, <sup>232</sup>Th and <sup>40</sup>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 <sup>-1</sup> )
Fluted Pumpkin	120	5	0.71	31.20

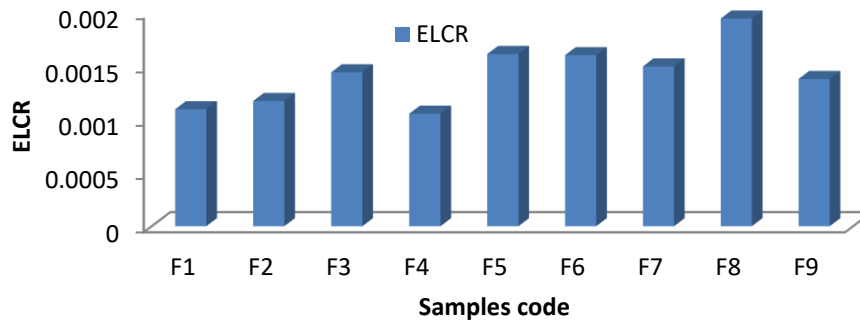
**Table 3.6: Estimated values of AED andELCRfor Flutedpumpkin leaf samples cultivated with inorganicfertilizers from the study area.**

LGA	Sample codes	AED (μSv.yr <sup>-1</sup> )	ELCR
Abak	F <sub>1</sub>	0.398	0.001095
	F <sub>2</sub>	0.426	0.001172
	F <sub>3</sub>	0.524	0.001441
	F <sub>4</sub>	0.383	0.001053
EtimEkpo	F <sub>5</sub>	0.586	0.001612
	F <sub>6</sub>	0.582	0.001601
	F <sub>7</sub>	0.544	0.001496

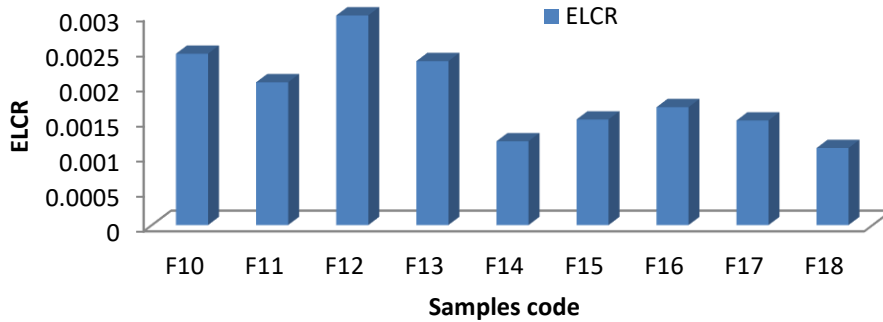
OrukAnam	F <sub>8</sub>	0.707	0.001944
	F <sub>9</sub>	0.501	0.001378
Mean		0.517	0.001421

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

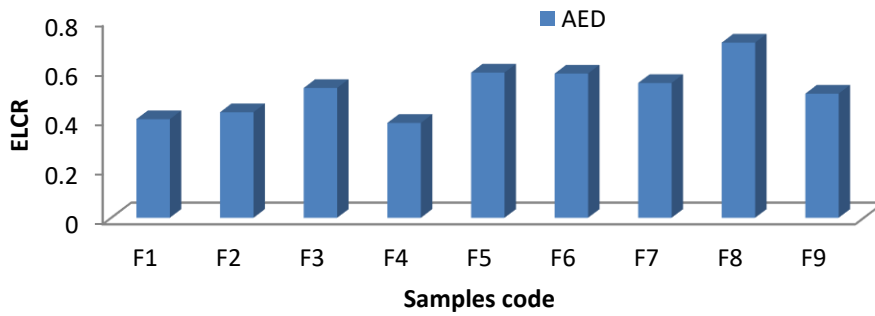
LGA	Sample codes	AED ( $\mu\text{Sv.yr}^{-1}$ )	ELCR
EssienUdim	F <sub>10</sub>	0.889	0.002445
	F <sub>11</sub>	0.741	0.002038
	F <sub>12</sub>	1.088	0.002992
	F <sub>13</sub>	0.851	0.002340
IkotEkpene	F <sub>14</sub>	0.425	0.001196
	F <sub>15</sub>	0.548	0.001507
Ikono	F <sub>16</sub>	0.612	0.001683
OrukAnam	F <sub>17</sub>	0.543	0.001493
Uyo	F <sub>18</sub>	0.400	0.001100
Mean		0.677	0.001866



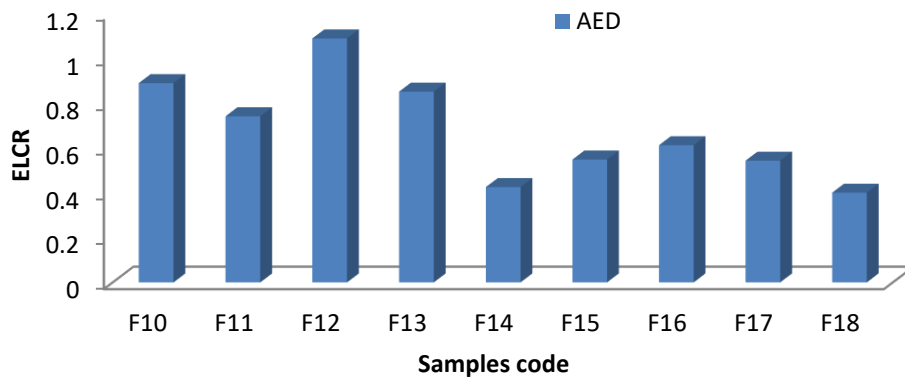
**Figure 3.5: Distribution of the excessive life time cancer (ELCR) risk in fluted pumpkin leaf samples Cultivated with inorganic fertilizers from the study area.**



**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.**



**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.**

### **fertilizers from the study area.**

### **3.3 DISCUSSION**

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

In the soil where the fluted pumpkin was cultivated with inorganic fertilizer, concentrations of  $^{238}\text{U}$ ,  $^{226}\text{R}$ ,  $^{232}\text{Th}$  and  $^{40}\text{K}$  ranges from  $35.71 \pm 2.23$  to  $67.19 \pm 3.64$  Bq/Kg,  $17.45 \pm 0.96$  to  $28.58 \pm 1.47$  Bq/Kg,  $23.83 \pm 1.27$  to  $36.97 \pm 1.98$  Bq/Kg and  $8.23 \pm 0.58$  to  $58.99 \pm 3.14$  Bq/Kg respectively. It is observed that the activity concentration of  $^{40}\text{K}$  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.

For fluted pumpkin cultivated without inorganic fertilizers, the activity concentration of  $^{238}\text{U}$  ranges from BDL to  $73.13 \pm 5.84$  Bq/Kg, for  $^{226}\text{R}$ , it ranges from  $4.81 \pm 0.84$  to  $28.23 \pm 2.03$  Bq/Kg, for  $^{232}\text{Th}$ , it ranges from  $4.81 \pm 0.84$  to  $65.32 \pm 3.59$  Bq/Kg and for  $^{40}\text{K}$ , it ranges from  $805.21 \pm 42.89$  to  $1582.93 \pm 83.72$  Bq/Kg. Essien Udim has the lowest activity concentration for  $^{40}\text{K}$  while Ikot Ikpeke has the highest for  $^{40}\text{K}$ . The highest activity concentration for  $^{238}\text{U}$  was found in Essien Udim. The highest in  $^{226}\text{R}$  and  $^{232}\text{Th}$  were also found in Essien Udim. It is observed that the activity concentration of  $^{40}\text{K}$  and  $^{238}\text{U}$  for fluted pumpkin cultivated with inorganic fertilizers is higher than that cultivated without inorganic fertilizers. But the reverse is the case for  $^{226}\text{R}$  and  $^{232}\text{Th}$ . For soil where the fluted pumpkin is cultivated without inorganic fertilizers, the mean activity concentration for all the radionuclides ranges from  $24.81 \pm 1.19$  Bq/Kg ( $^{226}\text{R}$ ) to  $27.52 \pm 2.90$  Bq/Kg ( $^{238}\text{U}$ ).

For fluted pumpkin leaves cultivated with inorganic fertilizer, the AED due to the consumption of this vegetable ranges from  $0.398 \mu\text{Sv.yr}^{-1}$  to  $0.707 \mu\text{Sv.yr}^{-1}$  with a mean value of 0.517. The values of AED for all the locations were below the recommended limit of  $1 \mu\text{Sv.yr}^{-1}$  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  $0.400 \mu\text{Sv.yr}^{-1}$  to  $1.088 \mu\text{Sv.yr}^{-1}$  with a mean of 0.677. The value of AED obtained in F<sub>12</sub> ( $1.088 \mu\text{Sv.yr}^{-1}$ ) is higher than the recommended limit of  $1 \mu\text{Sv.yr}^{-1}$ . 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  $0.0011 \mu\text{Sv.yr}^{-1}$  to  $0.001866 \mu\text{Sv.yr}^{-1}$ . 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, <sup>40</sup>K has the highest number of activity concentration for all the study areas and ranges from  $1127.59 \pm 59.64$  to  $1694.24 \pm 89.04$  Bq/Kg. The activity concentration of <sup>40</sup>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 <sup>40</sup>K and <sup>238</sup>U for fluted pumpkin cultivated with inorganic fertilizers is higher than for that cultivated without inorganic fertilizers. But the reverse is the case for <sup>226</sup>Ra and <sup>232</sup>Th. 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 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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