International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

http://ijpsat.ijsht-journals.org
Vol. 28 No. 2 September 2021, pp.546-554

Soil-To-Fluted Pumpkin Transfer Of Natural Radionuclides In Farm Lands In Akwa Ibom State, Nigeria

I. M. Essen[1], A. A. Essiett[2], I. E. Essien[2], K. R. Ekanem[1], M. C. Bede[2], I. O. Ehiwe[2]

[1]Department of Science Technology, Akwa Ibom State Polytechnic, Ikot Osurua. Nigeria
[2] Department of Physics, University of Uyo, Akwa Ibom State. Nigeria

Abstract – This work is aimed at evaluating the radionuclides transfer from soil to fluted pumpkin in farm lands in Akwa Ibom State, Nigeria. The activity concentrations of ^{238}U, ^{232}Th, ^{226}Ra and ^{40}K were measured in fluted pumpkin and soil samples using high purity Germanium (HPGe) Detector. The mean activity concentrations of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K in the soils samples ranged from 43. 26 ± 2.53 Bq/Kg to 80.11± 4.26 Bq/kg, 17.45 ± 0.96 Bq/ Kg to 28.71 ± 1.48 Bq/Kg, 23.83 ± 1.27 Bq/ Kg to 53.27 ± 2.84 Bq/Kg and 4.02 ± 0.36 to 43.83 ± 2.35 Bq/Kg respectively. The mean activity concentrations of radionuclides in the fluted pumpkin for ^{40}K, ^{238}U, ^{232}Th and ^{226}Ra ranged from 805.28 ± 42.89 to 1582.93 ± 83.72 Bq/Kg, below detection limit (BDL) to 86.96 ± 5.63 Bq/Kg, 4.81 ± 0.84 to 46 .23 ±3. 45 Bq/Kg and 7. 17 ± 0.83 to 25.28 ± 1.58 Bq/Kg respectively. The radionuclides transfer factor (TF) obtained in this work varies from farm to farm and ranged from 10.36 to 87.84 for ^{40}K, BDL to 1. 28 for ^{238}U, 0.13 to 0.95 for ^{232}Th and 0.31 to 0.92 for ^{226}Ra. The TF values for radionuclides obtained for this work were lower than 1 except for ^{40}K. This suggests that consumption of the fluted pumpkin in these areas might not pose a high radiological hazard to its consumers while for ^{40}K, the human body has an internal mechanism to eliminate its excess in the body.

Keywords – Radionuclides, Activity Concentration, Soil, Fluted Pumpkin, Transfer Factor.

I. Introduction

The continuous exposure of human beings to ionizing radiation from natural sources is an unavoidable feature of life on earth. This exposure to ionizing radiation arises from naturally occurring sources such as radiation from high-energy cosmic ray particles incident on the earth's atmosphere and from naturally occurring radionuclides of ^{238}Uand ^{232}Th decay series and ^{40}K that originated in the earth's crust and are present everywhere in the environment, including the human body itself [1]. There are also sources with artificial origin such as medical diagnostic and therapeutic procedures, radioactive material resulting from nuclear weapons testing, energy generation by means of nuclear power, unplanned events such as the nuclear power plant accidents at Chernobyl in 1986 and that of the great East-Japan earthquake and Tsunami of March 201I [1].

The contribution of radiation from soil to human exposure can either be whole body due to external radiation originating directly from primordial radionuclides present in soil, or internal due to ingestion of radionuclide contaminated food stuff [2]. The internal exposure to radiation affecting the respiratory tract could also be due to radon and its decay products emanating from soil, sediment and building materials [3]. Some of the radiation health effects due to long term exposure and inhalation of radionuclide are chronic lung disease, acute leucopoenia, anemia and necrosis of the mouth. Other possible effects include cataract, lung cancer and leukemia. The study of the distribution of these radionuclides helps in the determination of the radiological health implication of exposure to gamma rays and inhalation of radon and its daughter products. The radionuclides present in the environment transfer to plants through uptake from soil through roots and direct absorption through aerial parts of the plants [4]. Presence of radioactivity in plant organs has been reviewed by various workers [5], [6], [7]. It is reported that the elevation in the levels of radionuclides in the environment especially soil and plants may be due to several factors such as successive application of phosphate fertilizers, mining and milling operations, burning of fossil fuels amongst others [8]. It is therefore important to know the proportion transfer of radionuclide from soil to plant and their implications to human and animal health.

Different types of crops are grown traditionally in the study area. These include okra, maize, waterleaf, fluted pumpkin, cassava, yam, water yam and many others. Fluted pumpkin is one of the most consumed plants in the study area. It is a tropical vine grown in West Africa. It belongs to the species "Occidentalis" a member of the Cucurbitaceae family the botanical name is *Telfairia occidentalis.*Fluted pumpkin is also called fluted gourd and is known in the local language of the area Akwa Ibom State as ikong-ubong or Uku in Ibo language. The consumption rate of fluted pumpkin leaves is quite high in Akwa Ibom State and even in other states of the country. It is a staple food in the diet of South-South Nigeria, its tender shoots being basic ingredients for different kinds of porridge and soups served as a major delicacy in the study area. The fresh juice from-fluted pumpkin leaves is used as a medicinal drink to help correct anemia and other ailments due to its richness in iron and vitamins [9] . This work is aim at measurement of activity concentration of^{238}U, ^{226}R, ^{232}Thand ^{40}K in soil and fluted pumpkin grown on the soil of the studied area and the estimation of soil - to – fluted pumpkin transfer factor of these radionuclides. It is also necessary as there is no data on the soil –to- fluted pumpkin transfer factor for Akwa Ibom State, Nigeria.

II. Materials And Method

2.1 Study Areas

Akwa Ibom is a state located in the South-South geopolitical zone of Nigeria. It lies between latitudes 4°32'N and 5°33'N, and longitudes 7°25'E and 8^{0}25'E in the coastal southern part of the country. She is bordered on the coast by Cross River State, on the west by Rivers Stale and Abia State, and on the South by the Atlantic Ocean and the southernmost tip of Cross River State. The study area covered eighteen villages in seven local government areas (LGA) in the state. The local government areas considered was Ikot Ekpene, Essien Udim, Abak, Etim Ekpo, OrukAnam, Ikono and Uyo.

2.2 Sample Collection and Preparation

Sample sites were selected from cultivated farmlands in the study area**.** A total of 26 soils and 26 fluted pumpkin leaves samples were collected randomly from 18 villages. The farms were divided into evenly spaced sites with a distance of 20 m between each site for lager coverage of the farm according to [10]. At each sampling location, the soil surface was cleared of stones, pebbles, vegetation and roots. A soil sample of 2.0 kg (wet weight) was collected from each position with shovel and at a depth of 20 cm and corresponding edible part of fluted pumpkin leaves samples were collected in three different directions. At each sampling site, samples collected were thoroughly washed with tap water and then in distilled water to remove surface sand and placed into separate polyethylene bags [11]. Five samples of soil and fluted pumpkin were randomly collected at each location. 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 I50^{o}C in the lab. The samples were then ground to powdery form, sieved in order to homogenize it and weighed. The weight of the plant samples varied between 220g and 300g.

For soil sample preparation the method used by [10] and [11] was adopted. Soil samples were collected around the root area of the sampled plants. 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 plant 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 for analysis.

2.3 Activity Concentration Measurement

The detector used was a High Purity Germanium Detector (HPGe), model GC 8023, Serial number 9744 manufactured by Canberra with 2.3Kev,^{60}CO @ 1.33Mev Resolution and 80% relative efficiency. The detector was coupled to Multi Channel Analyzer and the software used was Genie 2K. About 500g of soil was measured from each soil sample and poured into a 500ml Marinelli beaker, about 200g was used for plant samples. The beaker was covered with beaker lid and sealed properly to ensure that there is no room for escape of any radioactive gas. It was left for 28 days to attain secular equilibrium before being moved for counting in the counting room. Each sample was counted for 1800 seconds and peak analysis was done with Genie 2000 software. Specific activity concentration was determined by the earlier efficiency done.

2.4 Activity Concentration in Samples

The activity concentration in unit of Bq kg^{-1}, for radionuclides with detected photopeak at energy E, is obtained from equation given by [12]

$$C = \frac{N_t}{TP_\gamma EM} \quad (1)$$

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.

2.5 Transfer Factor

The transfer model of radionuclides from soil to plant is represented by a parameter called transfer factor (TF), which is widely used to describe the soil to-plant transfer of radionuclide through the plant roots. The Soil-to-plant transfer factor for fluted pumpkin is estimated from the measured activity concentrations of radionuclides using the following relationship [13], [14].

$$TF = \frac{A_p}{A_s} \quad (2)$$

where A_p is the activity concentration of radionuclides in plant (Bq/Kg dry weight) and A_s is the activity concentration of radionuclides in soil (Bq/Kg dry weight)

III. Results And Discussion

Farmlands in eighteen villages within the seven local government areas of Akwa Ibom State, Nigeria were considered for this study as the villagers have large spans of cultivated farmlands of fluted pumpkin. The codes and locations of the farms in different local government areas are as presented in Table 1.

Table 1: The locations (degrees) and surface dose rate of samples collected from different locations in the study areas.

LGA	SAMPLE CODES	NORTH	EAST	$mR.hr^{-1}$
Abak	P1,S1	$04^0 58.692^1$	$007^0 46.969^1$	0.009
	P2,S2	$04^0 58.763^1$	$007^0 47.002^1$	0.022
Essien Udim	P3,S3	$05^0 08.361^1$	$007^0 42.892^1$	0.012
	P4,S4	$05^0 08.152^1$	$007^0 42.663^1$	0.011
Etim Ekpo	P5,S5	$04^0 58.593^1$	$007^0 46.265^1$	0.014
	P6,S6	$04^0 58.595^1$	$007^0 41.278^1$	0.016
Ikot Ekpene	P7,S7	$05^0 09.870^1$	$007^0 43.082^1$	0.015
	P8,S8	$05^0 10.758^1$	$007^0 41.635^1$	0.007
Ikono	P9,S9	$05^0 06.362^1$	$007^0 48.841^1$	0.009

Oruk Anam	P10,S10	$04^0 57.723^1$	$007^0 43.829^1$	0.007
	P11,S11	$04^0 57.734^1$	$007^0 43.838^1$	0.019
Uyo	S12	$05^0 05.992^1$	$007^0 55.619^1$	0.023

Source: Researchers (2021)

3.1 Activity concentration in soil samples

The activity concentration (AC) of ^{238}U, $^{226}R_a$, ^{232}Th and ^{40}K in the soils and fluted pumpkin are presented in Tables 2 and 3. It is observed that there is slight variation in the values of AC of radionuclides in farmlands within the same local government area as seen in Table 2 which are similar to work reported elsewhere [15], [16]. The mean activity concentrations of ^{238}U, ^{226}Ra, $^{232}Th$and ^{40}K in soils of the studied area ranged between 43. 26 ± 2.53 Bq/Kg to 80.11± 4.26 Bq/kg, 17.45 ± 0.96 Bq/ Kg to 28.71 ± 1.48 Bq/Kg, 23.83 ± 1.27 Bq/ Kg to 53.27 ± 2.84 Bq/Kg and 4.02 ± 0.36 to 43.83 ± 2.35 Bq/Kg respectively

It also observed that ^{40} K is not the dominant radionuclide among other radionuclides measured in the studied area, this is different from the usual trend in soil radioactivity where ^{40}K dominants as in results in reported works conducted in different parts of the state [11], [10], [17] and [18] and reports outside the state [6], [5], [19].This variation could be attributed to the difference in the soil texture and underlying rock formations and as usual in a local farms, fertilizer was not applied which could have raised the activity of potassium [2]. However, the mean activity concentration of ^{40}K is lower than the mean world value of 400 Bq/Kg while the mean activity concentration of other radionuclides are slightly higher than their world mean values ^{232}Th (30 Bq/kg) ^{238}U (35 Bq/kg) [1]. Figure 1 shows the distribution of the mean activity concentration of soil samples.

Table 2: Mean Activity concentration of radionuclides in Soil samples from study areas.

S/N	Location code	Concentration of radionuclides (Bq/Kg)				
		U^{238}	Ra^{226}	Th^{232}	K^{40}	Mean
1	S1	63. 87 ± 3. 46	27. 42 ±1.41	48. 88 ± 2.58	43.83 ± 2.35	46.00±2.45
2	S2	45. 40 ± 2.60	20.89 ± 1.28	30 87± 1.64	28. 30 ± 1.54	31.36±8.84
3	S3	59.69± 3.23	21.17 ±1.10	32 .91 ±1.75	16.47 ±0.86	32.56±1.73
4	S4	80.11± 4.26	28.71±1.48	43.48±2.27	19.11±1.09	42.28±2.27
5	S5	51.40±2.82	28.29±1.46	47.32±2.49	17.72±1.01	36.18±1.94
6	S6	48.41±2.67	23.67±1.22	34.14±1.80	4.02±0.36	28.06±1.51
7	S7	47.84±2.71	28.04±1.45	36.88±1.95	35.12±1.89	36.97±2.00
8	S8	46.81±2.68	19.17±0.99	31.57±1.68	17.83±1.03	28.84±1.59
9	S9	53.45±2.98	28.58±1.47	56.68±2.98	58.99±3.14	49.42±2.64
10	S10	43.26±2.53	17.45±0.96	23.83±1.27	8.23±0.58	23.19±1.33
11	S11	67.07±3.59	27.92±1.44	53.27±2.84	21.34±1.16	42.40±2.25
12	S12	73.79±3.87	25.61±1.32	44.73±2.36	39.22±2.09	45.84±2.41

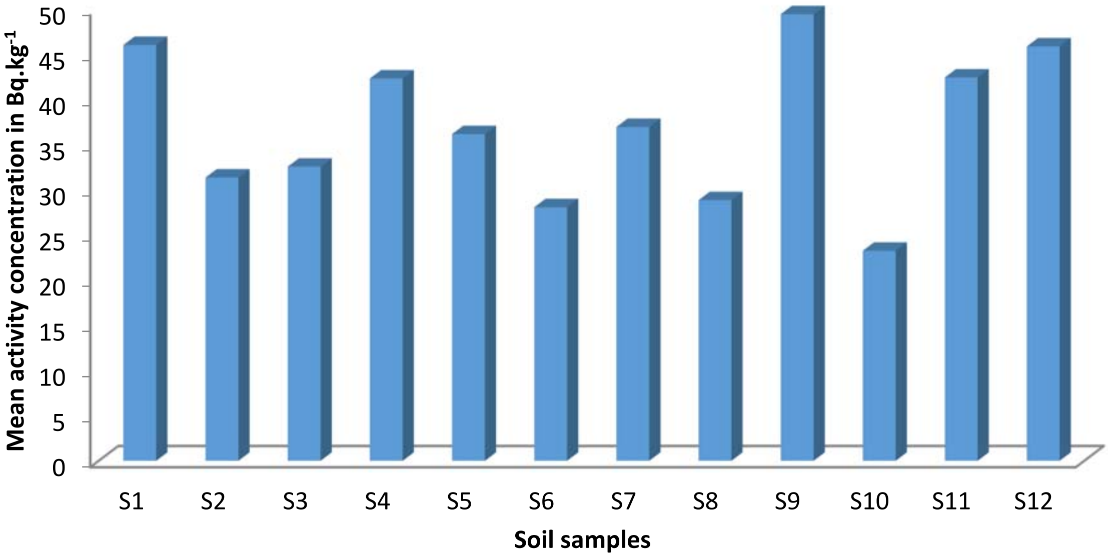

Figure 1: Distribution of the mean activity concentration of soil samples from the study areas

Source: Researchers (2021)

3.2 Activity concentrations in fluted pumpkin

It is known that there is transfer of radionuclides into plant from the soil due to the uptake of nutrients. Results for activity concentrations of the radionuclides determined in fluted pumpkin in the respective farms are presented in Table 3. The activity concentrations of radionuclides in the plant of potassium (^{40}K) was ranged between 805.28 ± 42.89 to 1582.93 ± 83.72 Bq/Kg (DW), the range of ^{238}U was between BDL – 86.96 ± 5.63 Bq/Kg (DW) and the activity concentrations of ^{232}Th ranged between 4.81 ± 0.84 to 46.23 ±3.45 Bq/Kg (DW) while the activity concentrations of Radium ranged between 7.17 ± 0.83 to 25.28 ± 1.58 Bq/Kg (DW).

Results presented show a high deposition of potassium in the fluted pumpkin while absorption of other radionuclides is low even where the activity concentration of the radionuclides in soil are lower. This also shows that the quantity of transferred radionuclide it to plant is not directly proportional to the quantity of the radionuclide present in the soil. Comparison of the activity concentration in fluted pumpkin in this study with previous study in the Akwa Ibom State is in impossible because literature searches show no result in the study area. Therefore we compare with study for other vegetables elsewhere in Nigeria. The mean value of the activity concentrations obtained for this study is higher than that obtained for water leaf (talinum triangulare), bitter leaf with a high absorption level of potassium in Delta State, Nigeria [18], [6]. However these values are higher than the world mean of 400 Bq/Kg for ^{40}K. This high value of potassium in the plantcould be as a result of the fact that it is an essential elemental requirement for proper plant growth [19], [6]. Furthermore [2] reported that the presence of potassium and calcium in the soil affect the transfer of other radionuclides into the plants which could also be responsible for the lower value of activity concentration of uranium and thorium presented. It is also observed that the mean activity concentration values obtained for ^{238}U and ^{232}Th are lower than the world mean of 35 Bq/Kg and 30 Bq/Kg respectively [1]. Figure 2 shows the distribution of the mean activity concentration of fluted pumpkin leaves (*Telfairia occidentalis)* samples.

Table 3: Activity concentration of radionuclides in fluted pumpkin leaves (*Telfairia occidentalis)*

S/N	Fluted pumpkin sample	Mean activity Concentration of radionuclides (Bq/Kg)				
		U^{238}	Ra^{226}	Th^{232}	K^{40}	Mean
1	P1	58.02±4. 63	25.28± 1.58	46. 23 ±3.45	1340.21 ±70. 88	367.38±20.13
2	P2	20. 57 ± 2.20	10 .68 ±1.49	16.03 ± 1.23	1418.77 ± 74.84	366.51±19.94

3	P3	8.06 ± 1.14	9.82 ±1.04	25.22 ± 1.59	1446. 67 ± 76.51	372.44±20.07
4	P4	16.50±1.99	8.85±0.61	9.02±0.61	1127.59±59.64	290.49±15.71
5	P5	BDL	15.43±0.98	36.16±2.02	805.28±42.89	214.22±11.47
6	P6	BDL	9.48±1.36	4.81±0.84	1582.93±83.72	399.30±21.48
7	P7	25.27±2.23	7.17±0.83	27.94±1.59	1286.69±68.05	336.76±18.17
8	P8	47.69±4.18	13.60±1.36	18.02±1.17	1260.88±66.69	335.04±18.35
9	P9	18.17±2.21	13.15±1.03	17.10±1.17	1444.44±76.40	373.21±20.20
10	P10	86.96±5.63	21.28±1.38	44.30±2.46	1361.34±72.00	378.47±20.37
11	P11	BDL	14.46±1.36	25.97±1.52	1538.42±81.37	394.71±21.06

Source: Researchers (2021).

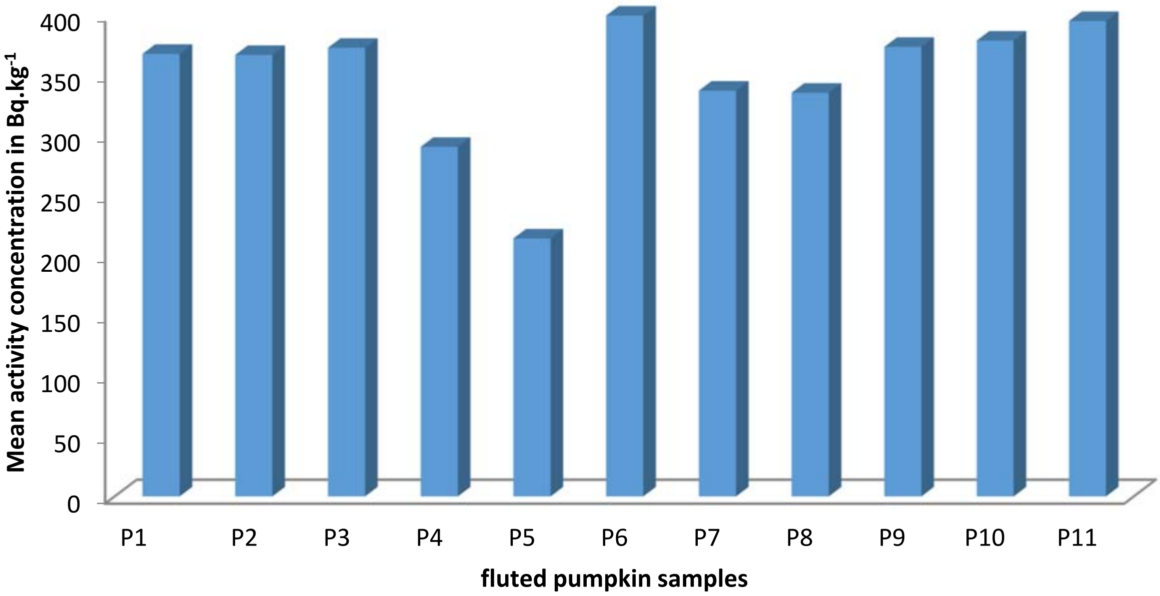

Figure 2: Distribution of the mean activity concentration of fluted pumpkin leaves

(*Telfairia occidentalis)* samples from the study areas.

Source: Researchers (2021).

3.3 Transfer factors of radionuclides from soil to fluted pumpkin (*Telfairia occidentalis)*

Transfer factor of radionuclides from soil to plant measures the contamination level of the plant by the radionuclide and also useful in evaluating radiological risk to humans when the plant is consumed. Using equation 2.0 the soil – to – fluted pumpkin transfer factor of ^{40}K, ^{238}U, ^{232}Th and ^{226}R were determined and presented in Table 4. Transfer factors obtained in this work varies from farm to farm with range between 10.36 to 87.84 for ^{40}K, BDL to 1. 28 for ^{238}U, 0.13 to 0.95 for ^{232}Th and 0.31 to 0.92 for ^{226}R. The TF value for potassium obtained for this work is higher while TF for Thorium is lower than those obtained elsewhere [7], [2],. It is also observed that the TFs of the radionuclides are higher while their activity concentrationsin the soil are low which agrees with findings obtained in other works showing that TF are not linearly related to radionuclide activity concentration in soil [2], [19]. Most TF values obtained for this work were lower than unity except for ^{40}K. 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. For the high TF of potassium 40 it is reported that the human body has an internal mechanism to control excess potassium in the body. However, the radiological health effect of the contaminated food could be reduced by cooking the food stuff before consumption as reported by [4]. Figure 3 shows the Percentage distribution of the radionuclides transfer from soil to fluted pumpkin obtained from the study areas. ^{40}K has the highest contribution with a percentage of 97% while ^{238}U, ^{232}Th and ^{226}R have approximately equal contribution. Figure 4 shows the distribution of the mean transfer factors of radionuclides from soil to fluted pumpkin leaf samples obtained from the study areas.

Table 4: Mean transfer factors of radionuclides from soil to fluted pumpkin leaf

S/N	Location Code	U^{238}	Ra^{226}	Th^{232}	K^{40}
1	T1	0.91 ± 8.09	0.92 ± 2.59	0.95 ± 6.03	30.58 ±73.23
2	T2	0.45 ± 4.80	0.51 ± 2.77	0.52 ± 2.87	50.13 ± 76.38
3	T3	0.14 ± 4.37	0.46 ± 2.14	0.77 ± 3.34	87. 84 ± 77. 37
4	T4	0.21 ± 6.25	0.31 ± 2.09	0.21 ± 2.88	59.01± 60.73
5	T5	BDL	0.55 ± 2.44	0.76 ± 4.47	10.36 ±43.90
6	T6	BDL	0.34 ± 2.81	0.13 ± 3.54	45. 07 ± 85. 61
7	T7	0.54 ± 4.96	0.37 ± 1.82	0.89 ± 3.27	72.16 ± 69.08
8	T8	0.89 ± 7.16	0.48 ± 2. 83	0.32 ± 4.15	21. 38 ± 69 .83
9	T9	0.35 ± 5. 09	0.67 ± 2.05	0.55 ± 2.85	56. 40 ±77.81
10	T10	1.28 ± 9.22	0.76 ± 2.82	0.83 ± 5.30	64. 09 ± 73.16
11	T11	BDL	0.57 ± 2.68	0. 58 ±3.88	39.23 ± 83.46

Source: Researchers (2021).

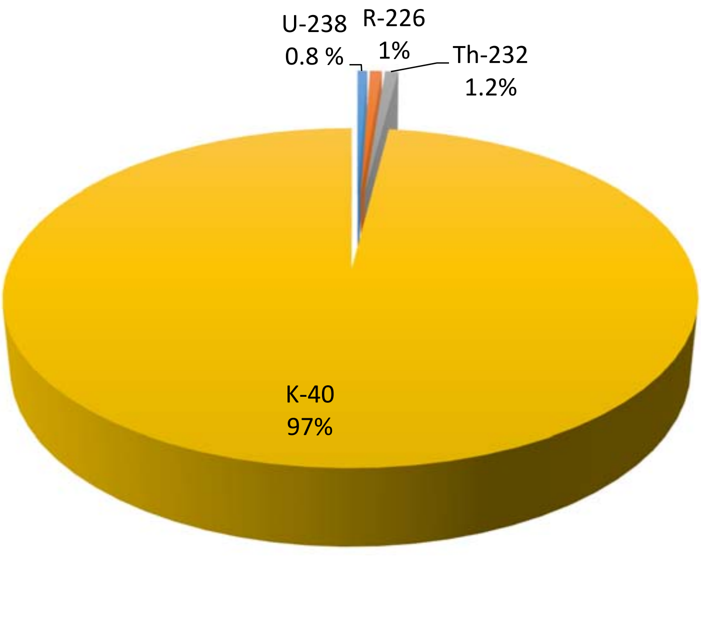

Figure 3: Percentage distribution of the radionuclides transfer from soil to fluted pumpkin.

Source: Researchers (2021).

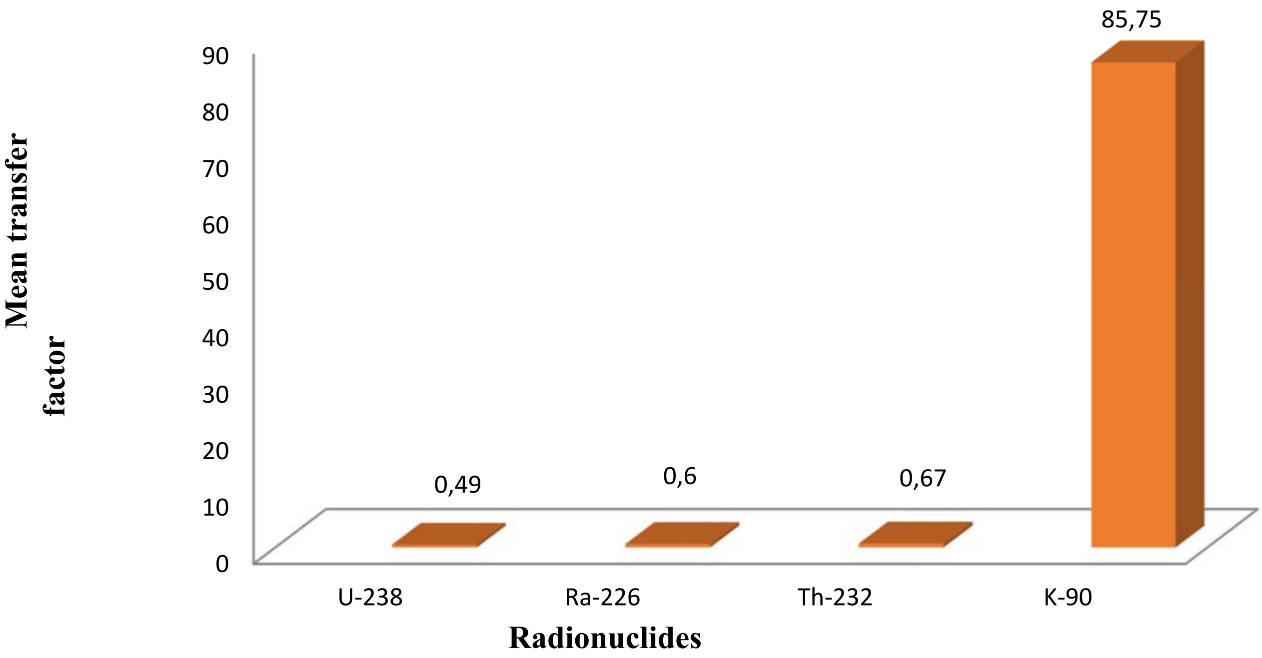

Figure 4: Distribution of the mean transfer factors of radionuclides from soil to fluted pumpkin leaf (*Telfairia occidentalis)* samples from the study areas.

Source: Researchers (2021).

IV. CONCLUSION

This study was conducted to provide baseline data for transfer factors of radionuclides from soil to fluted pumpkin leaf for Akwa Ibom State Nigeria. Gamma ray spectrometry method was used in measuring the activity concentration of the radionuclides.The mean activity concentration of the radionuclides in soils measured in this study were below the recommended mean world value of 400 Bq/Kg for ^{40}K, but higher for ^{238}U, ^{232}Th and ^{226}Ra. The TF results for this study were lower than the recommended value of 1 which suggests that consumption of fluted pumpkin leaf from the studied area may not pose any radiological health risk.

REFERENCES

[1] UNSCEAR (2000). Sources and Effects of Ionizing Radiation, united Nations Scientific Committee on the Effects of Atomic Radiation, United Nations New York .

[2] [Ononugbo C,. P, Azikiwe, O and Awiri, G. O (2019). Uptake and Distribution of Natural Radionuclides in Cassava Crops from Nigerian Government Farms. *Journal of ScientificResearch and Reports*, 23(5):P 1-15.

[3] Isinkaye M. O. and Emelue (2015). Natural Radioactivity Measurements and Evaluation of Radiological Hazards in Sediment of Oguata Lake, South East Nigeria. *Journal of Radiation Research and Applied Sciences* 8: 459-469.

[4] Jibiri,N. N, Alausa, S. K and Farai, I. P (2009). Assessment of External and Internal Doses due to Farming in High Background Radiation areas in old Tin Mining localities in Jos-Plateau, Nigeria. *Radioprotection* 44 (2) 139 – 151.

[5] Alausa, S. K., Odunaike, K and Adeniji, I. A (2017). Transfer Factor of Radionuclides from Soil- to palm Oil Produced from Elere Palm tree plantation near Ibadan Oyo, State, Nigeria. *Nigeria Journal of Pure and Applied Physics*, 7(1): 7-12.

[6] Adesiji, N. E and Ademola, J. A (2019). Soil – to – Maize Transfer Factor of Natural Radionuclides in a tropical Ecosystem of Nigeria. *Nigeria Journal of Pure and Applied Physics*, 9(1): 6-10.

[7] Amakom, C. M., Orji, C. E. Eke, B. C, Okoli, U A and Ndudi, C. S (2017). The Influence of Selected Soil Physicochemical Properties on Radionuclide Transfer in Cassava Crops, *International Journal of Plant and Soil Science,* 14(1): 1-7.

[8] Saleh I.H, Hafez A. F, ElananyN. H, MotowehH. A, NaimN. A (2006). Radiological Study on Soil Foodstuff and Fertilizers in Alexandria Region, Egypt.*Turkish Journal of Engineering and Environmental Science* 31(1) 9-7.

[9] Igbeneghu,O. A and Abdu A. B (2014). Multiple Antibiotic- Resistant Bacteria on Fluted Pumpkin. *Journal of Health Population and Nutrition* 32(2): 176-82.

[10] Essien, I. E.,Essiett, A. A., Ani, O. B., Peter, I. G and Udofia, A. E. (2017).Estimation of Radiological Hazard Indices Due to Radioactivity in Soils in IbionoIbom, Akwa Ibom State, Nigeria. *International Journal of Scientific and Research Publications,*7(5): 245-250

[11] Essien, I. E and Akpan, E. N (2016): Evaluation of Radiological Hazards Indices Due to Radioactivity in Quarry Sites in Itu, Akwa Ibom State, Nigeria. *International Journal of Scientific Research in Environmental Sciences,* 4(3): 71-77.

[12] IAEA (1989) Measurement of Radionuclide in Food and the Environment - Guidebook International Atomic Energy,Technical Report Series No. 295.

[13] IAEA (2010) Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Fresh Water Environments, Technical Report Series No. 472.

[14] FAO/IAEA/IUR (1998) Protocol for Experimental Study on the Uptake of Radionuclides from Soil to Plants by International Atomic Energy Agency Vienna.

[15] Usikalu, M. R., Oderinde, A., Adagunodo, T. A and Akinpelu. A. (2018).Radioactivity Concentration and Dose Assessment of Soil Samples in Cement Factory and Environs in Ogun State, Nigeria.*International Journal of Civil Engineering and Technology (IJCIET) 9:*. 1047–1059.

[16] Yehuwdah E. Chad-Umoren and Inimbom J. Umoh (2014) Baseline Radionuclide Distribution Patterns in Soil and Radiation Hazard Indices for Abak, Nigeria. *Advances in Physics Theories and Application, 3*2.

[17] Bede, M. C., Essiett, A. A.and Inam, E. (2015). An Assessment of Absorbed Dose and Radiation Hazard Index from Natural Radioactivity in Soils from Akwa Ibom State, Nigeria. *International Journal of Science and Technology, 4*(3): 80-89

[18] Chad Umoren, Y. E. and Umoh I J (2014). Baseline Radionuuclide Distribution Patterns in Soils and Radiation Hazards Indices for Abak, Nigeria, *Advances in Physics Theories and Application. 32*: 69-79.

[19] Ocheje, J. A andTyovenda, A. A (2020). Determination of the transfer factor and dose rate of radionuclides in some selected Crops in Kogi State, Nigeria.*IOSR journal of Applied Physics,* 12(3): 7-12.

[20] Tchokossa, P, Olomo, J. B, Balogun, F A and Adesanmi, C. A (2013). Assessment of Radioactivity Contents of Food in the Oil and Gas Producing Areas in Delta State, Nigeria. *International Journal of Science and Technology,* 3(4): 245-250.

[21] Avwiri, G.O., Ononugbo C.P. &Olasoji, J.M.(2021). Radionuclide Transfer Factors Of Staple Foods And Its Health Risks In Niger Delta Region Of Nigeria. *International Journal of Innovative Environmental Studies Research* 9(1):21-32,

[22] Golmakani, S., Moghaddam, M.V. and Hosseini, T. (2008). Factors affecting the transfer of radionuclides from the environment to plants. *Radiation Protection Dosimetry D*OI: 10.1093/rpd/ncn063

[23] Chen, S. B., Zhu, Y. G., Hu, Q. H., (2005): Soil to plant transfer of ^{238}U, ^{226}Ra and ^{232}Th on uranium mining-impacted soil from southeastern China. *J. Environ Radioactivity* 82: 213-216.