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Assessment of Activity Concentration and Transfer Factor of Radionuclides in Fluted Pumpkin Cultivated with and without Inorganic Fertilizer

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Abstract

The study examines the activity concentration (AC) of naturally occurring radionuclides and the extent of transfer of these radionuclides from soil to fluted pumpkin leaves. The study was carried out for fluted pumpkin cultivated with and without the use of inorganic fertilizers. The mean AC obtained for fluted pumpkin leaf samples cultivated with inorganic fertilizer were 43.50 ± 3.02 Bq/kg, 16.02 ± 1.18 Bq/kg, 29.11 ± 1.51 Bq/kg and 1324.92 ± 72.62 Bq/kg for ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K respectively. While the mean concentration obtained for fluted pumpkin leaf samples cultivated without inorganic fertilizer were 43.50 ± 2.03 Bq/kg, 16.02 ± 1.27 Bq/kg, 29.11 ± 1.58 Bq/kg and 1324.92 ± 70.09 Bq/kg for ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K respectively. The transfer factor (TF) from soil to the fluted pumpkin cultivated with inorganic fertilizers, for ^{238}U ranges from 0.013 to 1.049 with a mean of 0.572. For ^{226}R, ^{232}Th and ^{90}K, the transfer factors ranges from 0.338 to 1.140 with a mean of 0.549, 0.130 to 1.480 with a mean of 0.734 and 26.679 to 309.92 with a mean of 83.879 respectively. In this study the mean AC for ^{238}U, ^{226}R and ^{232}Th are higher than the recommended limits for both fluted pumpkin leaf samples cultivated with and without inorganic fertilizer.The transfer factor of ^{238}U in location (1.049) is more than the recommended limit of 1. Also, the transfer factors of ^{226}R from soil to the fluted pumpkin in locations (1.001) and (1.140) are all above the recommended values. The mean TF values obtained for ^{238}U, ^{226}Ra and ^{232}Th in this work were lower than unity which is the world recommended value. The TF for ^{40}K was however greater than 5.60 which is the world recommended value. For fluted pumpkin cultivated without inorganic fertilizers, the transfer factors for ^{238}U, ^{226}R, ^{232}Th and ^{90}K from the soil to the fluted pumpkin, ranges from 0.028 to 2.010, 0.334 to 1.219, 0.333 to 1.859 and 21.374 to 165.411 respectively. The transfer factors for ^{238}U, ^{226}R, ^{232}Th and ^{90}K in location F18 are all above the recommended values. It is observed that fluted pumpkin cultivated with inorganic fertilizers, has the highest TFs. This may be related to the morphological characteristics of the plants such as higher weight and size of fluted pumpkin leaves which allows a high amount of the radionuclides to be collected and accumulated.

Keywords: Radionuclides, Fluted Pumpkin, Activity Concentration, Fertilizer, Transfer Factor

1. Introduction

The ingestion dose is significantly influenced by naturally occuring radionuclides of ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K which are found in plants, animals, soil, water, and air within the biotic system [18, 19]. These radionuclides are unstable atoms which produce excess nuclear energy during radioactive decay to become stable. 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. 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 [20]. The exposure to ionizing radiation is caused by natural sources, including radiation from high-energy cosmic ray particles that reach the Earth's atmosphere, as well as naturally occurring radionuclides from the decay series of ^{238}U, ^{232}Th and ^{40}K which are found in the Earth's crust and are present in the environment, including the human body itself [1, 17].

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, 22]. 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, 9]. 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 [23]. 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 [21]. 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 [13]. This research work centered on measurement of natural radioactivity levels in fluted pumpkin leaves cultivated with and without inorganic fertilizer. A transfer factor which is the soil to plant transfer of through the plant root was also established.

2. Materials and Method

2.1 Study Area

In this study, some Local Government Areas (LGA) of Akwa Ibom State were considered. The Areas includes Abak, Etim Ekpo, Oruk Anam, Essien Udim, Ikot Ekpene, Ikono and Uyo.Akwa Ibom is a State in Nigeria located in the southern coastal part and is in 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.

2.2 Sample Collection and Preparation

Factors considered in selection of sample sites include: Farmlands where fluted pumpkin 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 80ºC 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 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. Activity concentration was determined by the earlier efficiency calibration done. The radionuclides considered were ^{238}U, ^{232}Th, ^{226}Ra and ^{40}K.

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 Radionuclide Transfer Factor

The transfer model of radionuclides from soil to plant is represented by a parameter called transfer factor (T_F), 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 equation 2.2 [13, 14].

$$T_F = \frac{A_P}{A_S} \qquad 2.2$$

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)

3. Results and Discussion

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

Tables 1 to 4 present the values of 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. Figures 5 to 8 show the distribution of the 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 in all the locations. Figures 9 and 10 show 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 contributed the remaining portion which is just 3% of the total distribution.

Table 1: Activity concentration of ^{40}K, ^{226}Ra, ^{238}U and ^{232}Th in Bq/Kg for fluted pumpkin samples cultivated with inorganic fertilizers in 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
Etim Ekpo	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
Oruk Anam	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

BDL: Below detection limit

Table 2: Activity concentration of ^{40}K, ^{226}Ra, ^{238}U and ^{232}Th in Bq/Kg for soil where fluted pumpkin samples was cultivated with inorganic fertilizers in 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
Etim Ekpo	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
Oruk Anam	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: Activity concentration of ^{40}K, ^{226}Ra, ^{238}U and ^{232}Th in Bq/Kg for fluted pumpkin samples cultivated without inorganic fertilizers in the study area

LGA	Sample codes	^{238}U	^{226}Ra	^{232}Th	^{90}K
Essien Udim	F_{10}	50.47±4.08	28.23±2.03	24.10±4.08	1293.38±68.41
	F_{11}	73.13±5.84	25.94±1.48	65.32±3.59	1499.98±79.33
	F_{12}	50.47±4.23	21.67±1.24	49.27±2.71	1227.26±64.91
	F_{13}	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
Ikot Ekpene	F_{14}	BDL	9.48±1.36	4.81±0.84	1582.93±83.72
	F_{15}	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_{16}	BDL	14.46±1.36	25.97±1.52	1538.42±81.37
Oruk Anam	F_{17}	18.17±2.21	13.15±1.03	17.10±1.17	1444.44±76.40
Uyo	F_{18}	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 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 in the study area

LGA	Sample codes	^{238}U	^{226}Ra	^{232}Th	^{90}K
Essien Udim	S_{10}	62.29±3.36	28.19±1.45	47.08±2.48	42.41±2.27
	S_{11}	69.70±3.76	22.76±1.18	44.13±2.35	43.08±2.32
	S_{12}	59.63±3.26	31.32±1.61	55.44±2.92	46.002.46
	S_{13}	65.92±3.52	27.08±1.40	37.49±1.99	23.50±1.32
Ikot Ekpene	S_{14}	47.84±2.71	28.04±1.45	36.88±1.95	35.12±1.89
	S_{15}	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
Oruk Anam	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

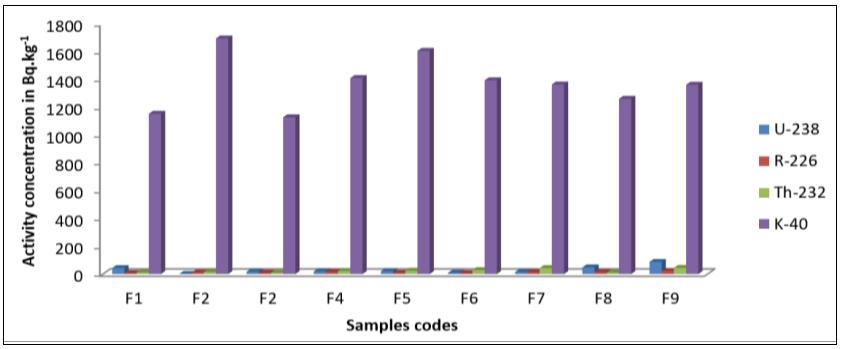

Fig 1: Distribution of the activity concentration in Bq/Kg of the fluted pumpkin samples cultivated with inorganic fertilizers in the study area

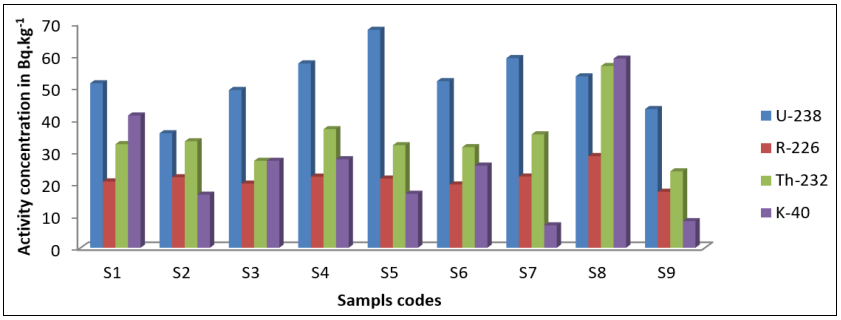

Fig 2: Distribution of the activity concentration in Bq/Kg of the soil where fluted pumpkin samples is cultivated with inorganic fertilizers in the study area

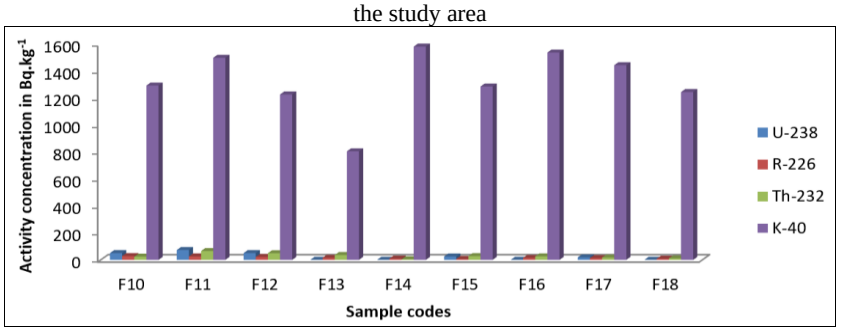

Fig 3: Distribution of the activity concentration in Bq/Kg of the fluted pumpkin samples cultivated without inorganic fertilizers in the study area

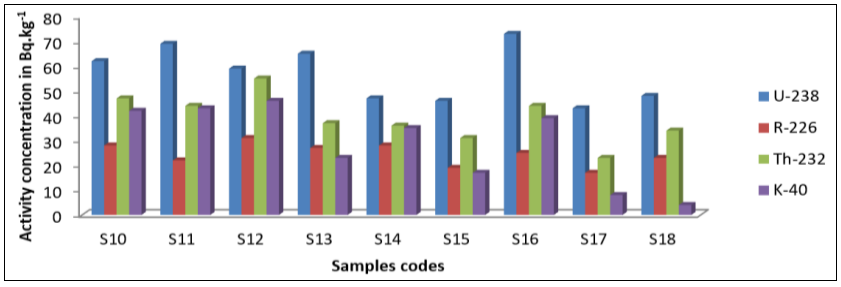

Fig 4: Distribution of the activity concentration in Bq/Kg of the soil where fluted pumpkin was cultivated without inorganic fertilizers in the study area

3.2 Radionuclide Transfer factors of Soil to Fluted Pumpkin

Tables 5 and 6 show the transfer factors of the radionuclides (^{238}U, ^{226}Ra, ^{232}Th and ^{90}K) from the soil to the fluted pumpkin cultivated with and without inorganic fertilizers in the study areas.

Table 5: Tranfer factors (T_F) of the radionuclides from soil to fluted pumpkin samples cultivated with inorganic fertilizers from the study areas

LGA	Sample codes	^{238}U	^{226}Ra	^{232}Th	^{90}K
Abak	TF1	0.841	0.334	0.354	27.936
	TF2	0.028	0.474	0.437	102.37
	FT3	0.335	0.443	0.333	41.593
	TF4	0.322	0.664	0.599	51.094
Etim Ekpo	TF5	0.288	0.393	0.743	95.365
	TF6	0.175	0.349	0.893	54.410
	TF7	0.255	0.589	1.211	195.361
Oruk Anam	TF8	0.892	0.475	0.177	21.374
	TF9	2.010	1.219	1.859	165.411
	Mean	0.572	0.549	0.734	83.879

Table 6: Tranfer factors (T_F) of the radionuclides from soil to fluted pumpkin samples cultivated without inorganic fertilizers in the study area

LGA	Sample codes	^{238}U	^{226}Ra	^{232}Th	^{90}K
Essien Udim	TF10	0.810	1.001	0.512	30.497
	TF11	1.049	1.140	1.480	34.818
	TF12	0.846	0.692	0.889	26.679
	TF13	0.015	0.570	0.964	34.267
Ikot Ekpene	TF14	0.021	0.388	0.130	45.072
	TF15	0.539	0.374	0.885	72.640
Ikono	TF16	0.013	0.565	0.581	39.225
Oruk Anam	TF17	0.420	0.754	0.717	175.509
Uyo	TF18	0.021	0.366	0.332	309.920
	Mean	0.415	0.644	0.720	85.403

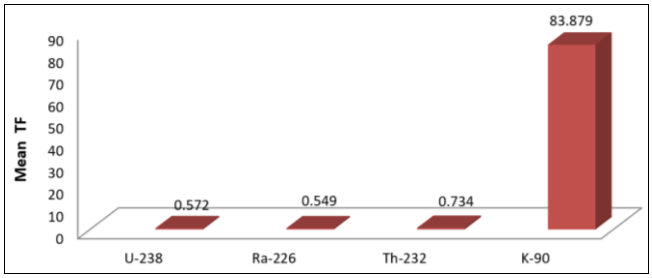

Fig 5: Distribution of the mean transfer factors of radionuclides from soil to fluted pumpkin leaf (*Telfairia occidentalis)* samples cultivated with organic fertilizers in the study area

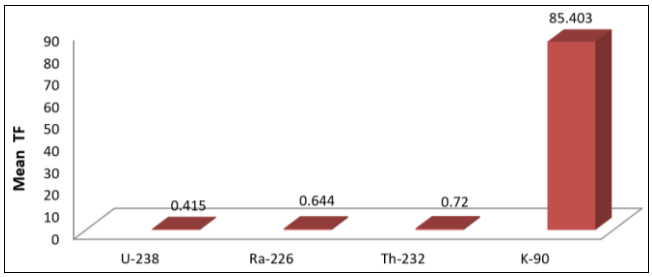

Fig 6: Distribution of the mean transfer factors(TF) of radionuclides from soil to fluted pumpkin leaf (*Telfairia occidentalis)* samples cultivated without organic fertilizers in the study area.

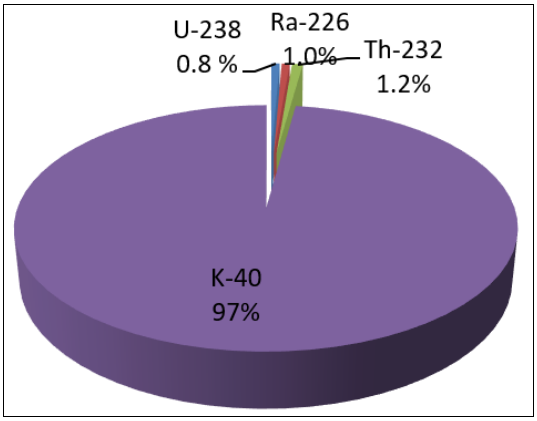

Fig 7: Percentage distribution of radionuclides transfer from soil to fluted pumpkin cultivated with inorganic fertilizers

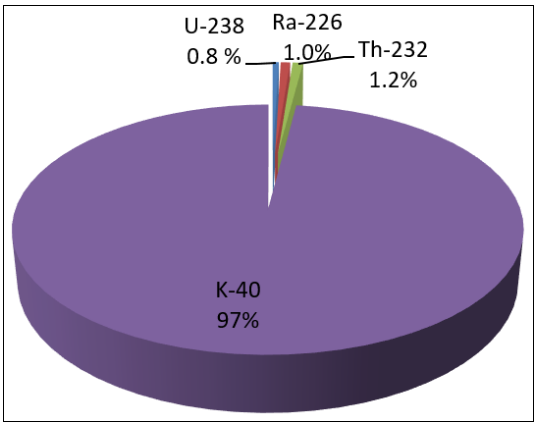

Fig 8: Percentage distribution of radionuclides transfer from soil to fluted pumpkin cultivated without inorganic fertilizers

3.3 Discussion

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 for fluted pumpkin cultivated with inorganic fertilizer. The overall mean for ^{238}U in the different locations 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 number 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. It is observed that the activity concentration of ^{40}K in the fluted pumpkin is 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 through the roots and stems [12, 11].

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). The mean ACs obtained for all radionuclides in fluted pumpkin leaf samples cultivated with the use of inorganic fertilizer and those without are the same except for variations in the error limits. And also from the results obtained in this study the mean AC for ^{238}U, ^{226}R and ^{232}Th are higher than the recommended limits for both fluted pumpkin leaf samples cultivated with and without inorganic fertilizer.

For the transfer factors from soil to the fluted pumpkin cultivated with inorganic fertilizers, the transfer factor of ^{238}U ranges from 0.013 (F7) to 1.049 (F2) with a mean of 0.572. For ^{226}R, ^{232}Th and ^{90}K, the transfer factors ranges from 0.338(F5) to 1.140 (F2) with a mean of 0.549, 0.130 (F5) to 1.480 (F2) with a mean of 0.734 and 26.679 (F3) to 309.92 (F9) with a mean of 83.879 respectively. The transfer factor of ^{238}U in location F2(1.049) is more than the recommended limit of 1 [13]. Also, the transfer factors of ^{226}R from soil to the fluted pumpkin in locations F1(1.001) and F2(1.140) are all above the recommended values. The high TF for ^{40}K may be due to the continuous accumulation of ^{40}K through root uptake where K is an essential macronutrient for metabolism and taken up by plants from the soil in varying amounts [11, 13]. The mean TF values obtained for ^{238}U, ^{226}Ra and ^{232}Th in this work were lower than unity which is the world recommended value. The TF for ^{40}K was however greater than 5.60 which is the world recommended value [13]. 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 ^{40}K it is reported that the human body has an internal mechanism to control excess potassium in the body.

For fluted pumpkin cultivated without inorganic fertilizers, the transfer factors for ^{238}U, ^{226}R, ^{232}Th and ^{90}K from the soil to the fluted pumpkin, ranges from 0.028 (F11) to 2.010 (F18), 0.334(F10) to 1.219 (F18), 0.333 (F12) to 1.859 (F18) and 21.374 (F17) to 165.411 (F18) respectively. The transfer factors for ^{238}U, ^{226}R, ^{232}Th and ^{90}K in location F18 are all above the recommended values. It is observed that fluted pumpkin cultivated with inorganic fertilizers, has the highest TFs. This may be related to the morphological characteristics of the plants such as higher weight and size of fluted pumpkin leaves which allows a high amount of the radionuclides to be collected and accumulated [12].

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 through the roots and stems. 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 transfer factors of ^{226}R from soil to the fluted pumpkin in locations F1(1.001) and F2(1.140) are all above the recommended values. The mean TF values obtained for ^{238}U, ^{226}Ra and ^{232}Th in this work were lower than unity which is the world recommended value. The TF for ^{40}K was however greater than 5.60 which is the world recommended value.

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