Original Research Article

RADIONUCLIDE TRANSFER RATIO FROM SOIL TO CROPS IN SELECTED FERTILIZED FARMS AND ESTIMATION OF ITS HEALTH RISK IN RIVERS STATE OF NIGERIA.

Abstract

The study was carried out to investigate the transfer ratio of radionuclide from soil to crops of the selected fertilized farmers in Rivers State Nigeria. Using a well calibrated sodium iodide (NaI) detector. The activity concentrations of ^{40}K, ^{234}U, and ^{232}Th in crops and soils of the selected fertilized farmers of Rivers State have been determined. The activity concentration of radionuclides of ^{40}K, ^{234}U, and ^{232}Th were all higher than its respective control values, which show that the fertilized farms contain more radionuclide than the unfertilized farms(control) and this may be due to the long use of inorganic fertilizers during cultivation on the selected Agricultural Development programme farms (Fertilized Farms). This variation may be due to differences in organic matter, soil content and type of soil of the selected farms. The mean transfer factor obtained is of the order ^{234}U < ^{232}TH < ^{40}K which shows that activity concentration of natural radio isotopes within the study area are high and also the rate at which the radionuclides are transfer from soil to crops is also high. The result obtained show that there is high transfer ratio of radionuclide from soil to crops of the selected fertilized farms and this requires that the uses of NPK fertilizers should be under radiological control for consumption safety.

Keywords: Radionuclides, Radionuclide, Transfer, Activity concentration, Fertilized farms

1. INTRODUCTION

Human environment contains various types of contamination which attracted the attention of research in our present society. Most of this contamination occur naturally or as a result of our daily activities here on earth. The crops raised from this contaminated farms or environments accumulate radionuclides that could form a direct route of radiation exposure to human when ingested or through the consumption of the crops obtained from contaminate farms [9]. Natural radioactivity has always been present and broadly distributed in the earth's crust and the atmosphere, either as natural radioactivity of uranium (^{238}U) and thorium(^{232}Th) decay series and radioactive potassium (^{40}K), or as cosmic radiations that are produced constantly in the atmosphere [11,5,4]. The utilizations of phosphate fertilizer globally for the increased in crop productions and for land reclamation has risen to more than 30 million tons annually [3]. The major raw materials for the production of chemical fertilizers must therefore supply the essential nutrients necessary for plant growth and the plant transfer this chemical to the tubers. Natural radioactivity of mainly Uranium (^{238}U), Thorium (^{232}Th) and Potassium (^{40}K) seen in phosphate fertilizers emanate from the phosphate ore, (due to geological reasons) which is the main raw material used for phosphate fertilizer production. Transfer factor (TF) is a necessary parameter that encompasses influence of physicochemical properties of soil, environmental conditions, and types of radionuclides [2]. The migration of radionuclides in the soil to crops is complex and the transfer factor assessment models is commonly utilized to describe the translocation of radionuclides among different environmental matrices, it is defined as the ratio of the concentration of radionuclide in the destination matrix and that in the departure matrix. The transfer factor depends on chemical, physiological and ecological [17].

Rivers state environment is naturally blessed with different resources which has attracted industrials activities and farming activities. The industrials waste and operation of these industries could directly or indirectly contaminate the soil and crop from some of the local government area such as Khana, Gokana Eleme and Ahoada. The utilization of chemical fertilizers increases the concentration of phosphate and uranium in the soil and also increases the concentration in nutrients. This could also have some harmful effect in the long run if not checked. The Consumption of crops containing high concentration of radionuclides may be dangerous to human health. The present of radionuclide in the consumed food will continues to irradiate the body as long as it remains radioactive and stays in the body (FAO, 1986). Researches have shown that any dose of radiation increases an individual risk of developing cancer. The concentration of radionuclide in the food chain and the continue consumption of such food adds to the cumulative risk of developing skin burn, leukemia, cancer and other related diseases [12].

The large data dispersion is also due to the fact that some of the ratios between two specific activities are in fact time-dependent, so that the assumption of an equilibrium model is not always valid. The research work aims investigate the transfer ratio of radionuclide from soil to crops of the selected fertilized farmers in Rivers State where crops are cultivated in large quantities for human consumption.

2. Study Area

This research work was carried out in selected fertilized farms within six Local Government Area of Rivers State.figure1 shows the maps the study area. The following Local Government Areas considered for the research were Ahoada, Emohua, Obio/Akpo, Eleme, Gokana and Khana Local Government Area and they are shown on the map with a red colour. The samples collected from the selected Fertilized Famers were label with different code for a proper identification during the analysis.

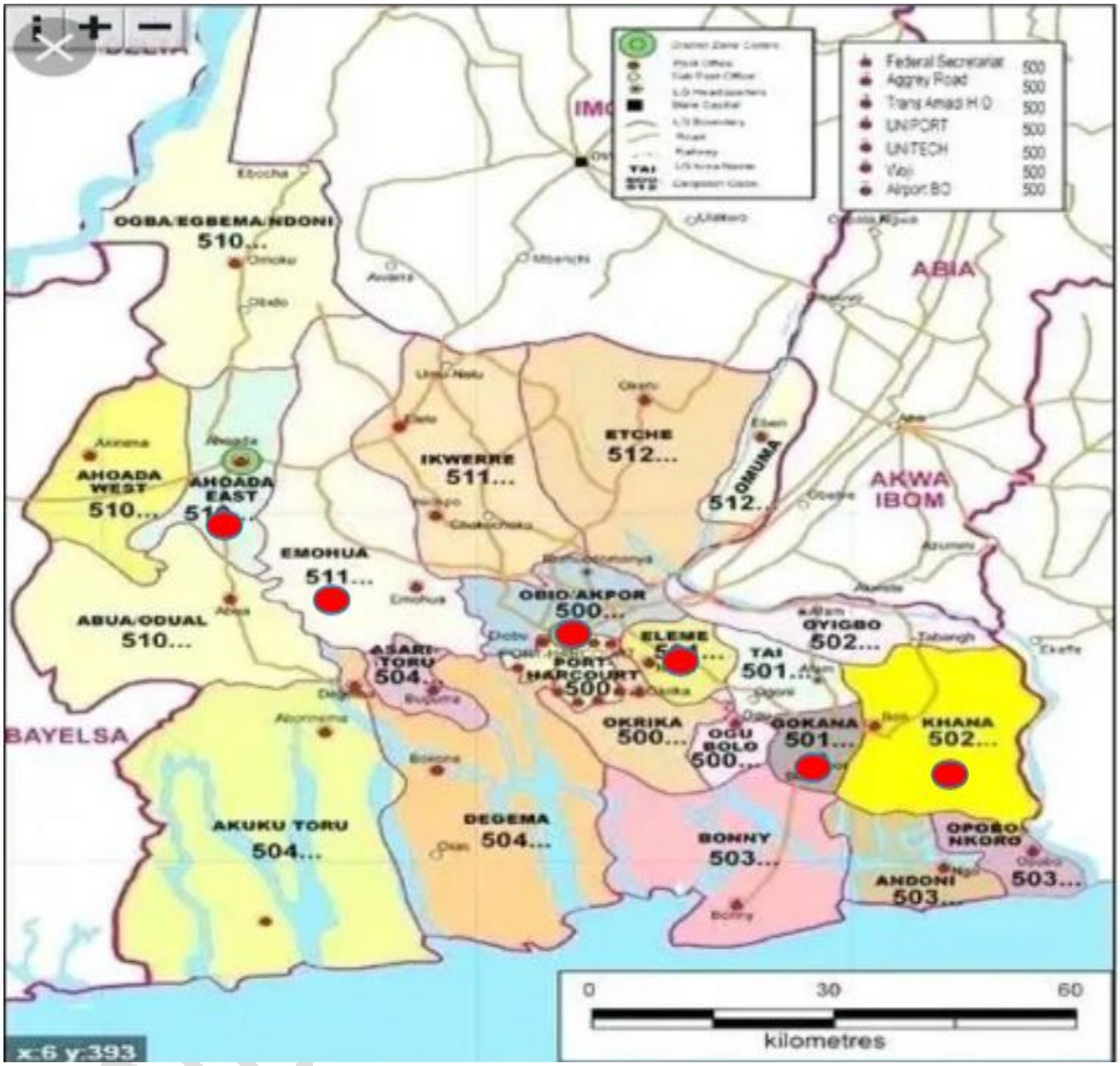

Fig .1: The Map of Study Area

3.1 Materials and Methods

3.1 Materials

Gamma-ray spectrometry system was use for analyzing the samples using Canberra 3 × 3 model 802. The Thallium-activated Sodium Iodide [NaI] detector and installed in a 100mm thick lead castle. The detector is connected to an amplifier linked to a computer program GENIE 2 K Window that correlated gamma energies to a number of possible isotopes. The sample was placed the marinelli beaker and then made to sit on the Sodium Iodide (NaI) detector. Shielding from background (environmental) radiation was achieved by counting in Canberra 100 mm thick lead castle. The energy resolution for the detector using Cs137 from International Atomic Energy Agency (IAEA) is 7.5% at 662KeV Cs-137 line. The standard and the sample were counted for a period of 36,000 seconds to acquire spectral data for a better counting statistics and evaluation. The activity concentration of ^{238}U, ^{232}Th and ^{40}K were determined after correction for background and inhomogeneity. The crops and soil samples were symmetrically placed on the top of the detector and the net area under the corresponding peaks in the energy spectrum was computed by subtracting counts due to Compton scattering of higher peaks and other background sources from the total area of the peaks. From the net area of a certain peak, the activity concentrations in the samples were obtained using the equation below

$$C(Bqkg-1) = \frac{\mathrm{Cn}}{\varepsilon \mathrm{P\gamma Ms}} \quad (1)$$

where C is the activity concentration of the radionuclide in the sample given in Bq kg–1, Cn is the count rate under the corresponding peak, e is the detector efficiency at the specific c-ray energy, Pc is the absolute transition probability of the specific c-ray, and M_s is the mass of the sample (kg).

3.2 Methods

3.2.1 Samples collection

The samples were collected from selected fertilized farms within three Senatorial districts of Rivers State namely: Rivers-East Senatorial district, Rivers West Senatorial district and Rivers-South Senatorial district. Sixty-four (64) samples were collected for the purpose of the research work. Thirty-two samples were crops and the other thirty-two samples were soil. This samples were collected from six different fertilized farms of the selected Local Government Areas within the Senatorial district. The following crops were collected from the selected fertilized farmers: yam, cassava, coco-yam, three leave yam, maize and potato.

3.2.2 Sample Preparation

The 64 samples collected for the purpose of the study were properly washed with pipe-borne water to remove mud and dust. The Crops were peeled and sun dried for twenty-eight days to get constant dry weight, and then grind with hand grinding machine and later packed into a new well label black polythene bags accordingly for proper identification. The maize samples collected from the selected fertilized farmers were detached from the cob, air dried for twenty-eight days to get a constant dry weight and then grind using hand grinding machine and packed into a new black polythene bags well labelled. The soil samples collected from the selected fertilized farms were filtered, sun dried and packed into a well labelled black polythene bags for a proper identification.

3.3 Radionuclide Uptake and Transfer factor

The earth contains varied degrees of radioactivity due to chain decay of ^{226}Ra and ^{232}Th [14]. Natural radionuclides are in different concentrations in environmental media. Human activities like routine and accidental discharge of nuclear waste, production of energy, use of fertilizers and mining have altered their natural settings in the environment.

According to [13] absorption of radioisotopes is enhanced at the initial plant growth stage meaning that absorption varies with plant growth. The transfer factor depends also on the mass of plant. Equation 3 below expresses the dependence on mass by transfer factor.

$$\boldsymbol{TF(m) = TF(0)(\frac{m}{m_0})^{\alpha-1}} \quad (2)$$

Where m_0 is the initial plant mass, TF (0) is the initial value of the transfer factor at t = 0, m = m_0, α is a function that determines the rate of decrease of transfer factor with increasing plant mass. Transfer factors can also be defined based on dry weight, as ratio of activity content ($Bqkg^{-1}$) in plant to activity content ($Bq \cdot kg^{-1}$) of soil or can be based on surface area of soil and expressed as $Bq \cdot kg^{-1}$ dry weight of plant to $Bq \cdot m^{-1}$ in soil [6] The recommended soil depth is 10 cm for grass and 20 cm for all other crops and trees. The radioisotope content at this depth is homogeneous. This transfer factor is expressed as:

$$TF = \frac{\textit{activity concentration of plant}(Bq.kg{-}1\ \textit{dry weight})}{\textit{activity concentration of soil}\ (Bq.kg{-}1\ \textit{dry weight})} \quad (3)$$

In this work, equation 2 was adopted because it was impossible to monitor the different plant growth stages to note mass of crops.

4. RESULTS

Table 1: Specific Activity Concentration of ^{40}k, ^{234}U and ^{232} Th in Soil Samples from the selected Fertilizer Farms

S/N	LOCATION	SAMPLE CODE	^{40}K (Bq /Kg)	^{234}U (Bq/Kg)	^{232} Th (Bq/Kg)
1	Gokana	CVT1	6.64±0.56	9.73±2.06	2.43±0.24
2	,,	CVT2	8.90± 0.23	2.52±0.44	2.77±0.20
3	,,	CYMT	106.63±8.66	13.19±4.08	1.42±0.015
4	,,	TLYMT1	124.73±9.76	10.45±2.27	2.42±0.23
5	,,	TLYMT2	31.79±2.80	23.35±4.28	1.73±0.16
6	Khana	CON	56.53±5.02	16.22±3.22	1.15±0.12
7	,,	YMT	115.07±9.30	14.14±2.79	21.2±0.22
8	,,	TLYT	50.16±3.08	BDL	8.69±0.61
9	,,	KPOT	171.01±.14.59	23.43±5.09	10.00±0.90
10	,,	KCVT1	55.53±4.80	BDL	4.32±0.38
11	,,	KCVT2	27.56±1.68	BDL	0.41±0.03
12	Emohua	EMCVT	66.59±6.18	18.88±3.66	7.23±0.63
13	,,	EMCYMT	168.59±12.73	4.04±0.87	0.68±0.07
14	,,	EMCYMT2	81.88±6.56	8.94±1.84	3.08±0.28
15	Eleme	ELCVT1	161.15±9.69	3.22±0.49	0.29±0.02
16	,,	ELCVT2	81.88±4.92	8.94±1.40	3.08±0.22
17	,,	ELYMT	22.47±2.01	11.53±2.61	14.12±1.20
18	,,	ELYMT2	99.38±8.63	15.21±3.09	5.34±0.50
19	Obio/Akpo	CVT1	72.63±6.31	22.99±4.44	6.86±0.59
20	,,	CON	29.78±2.65	18.31±3.90	5.47±0.05
21	,,	YMT1	30.9±2.80	25.58±4.38	3.06±0.28
22	,,	YMT2	24.75±2.34	14.87±2.81	1.58±0.16
23	,,	YMT3	169.64±6.71	5.03±0.57	1.58±0.09
24	Ahoada	CVT1	81.88±6.56	8.94±1.84	3.08±0.28
25	,,	CVT2	164.11±4.51	4.32±0.59	0.89±0.01
26	,,	CVT3	86.24±4.92	8.34±1.80	2.07±0.26
27	,,	CYMT1	23.57±1.01	12.83±1.51	15.22±1.90
28	,,	CYMT2	99.58±3.23	13.21±1.09	4.74±0.60
29	,,	CON	82.23±2.30	24.19±2.24	6.86±0.59
30	,,	TLY	29.38±1.35	19.41±1.90	7.40±0.08
	Mean		**75.35±2.35**	**12.02±2.25**	**4.316±0.32**
31	Control 1		3.91±0.80	2.58±1.38	1.06±0.22
32	Control 2		4.75±1.24	11.07±0.81	0.38±0.06

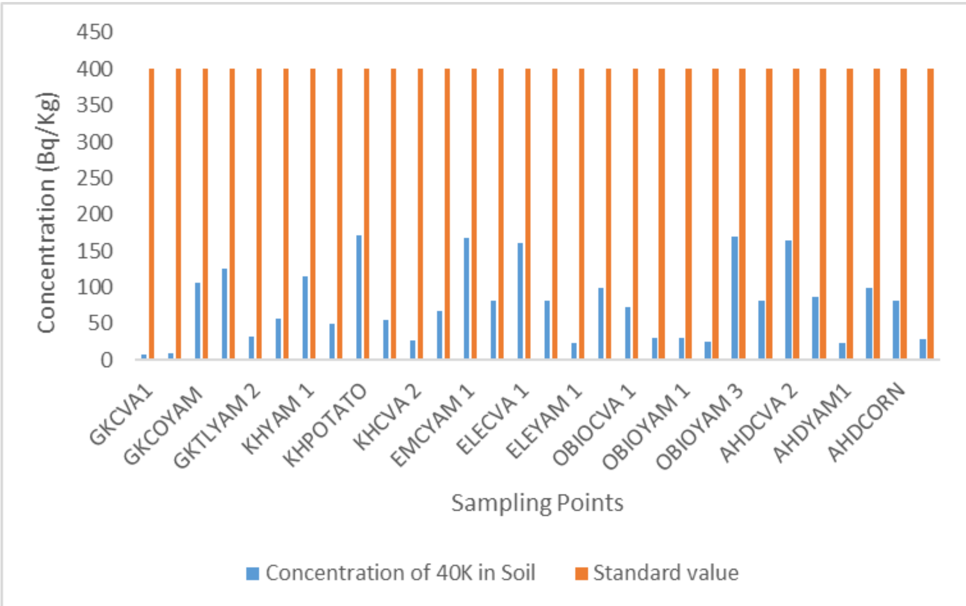

Fig .2: Concentration of ^{40}K in soil with standard

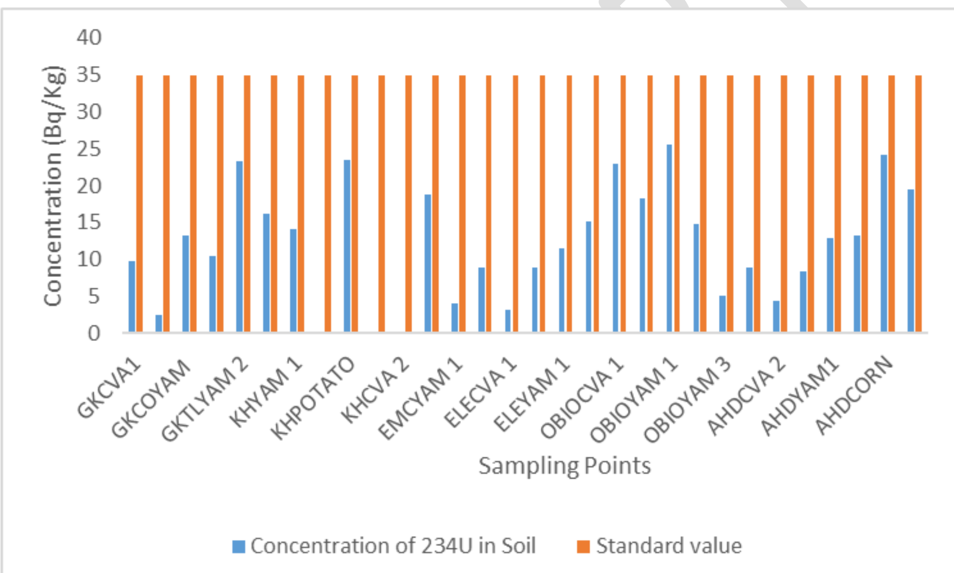

Fig .3: Concentration of ^{234}U in soil with standard

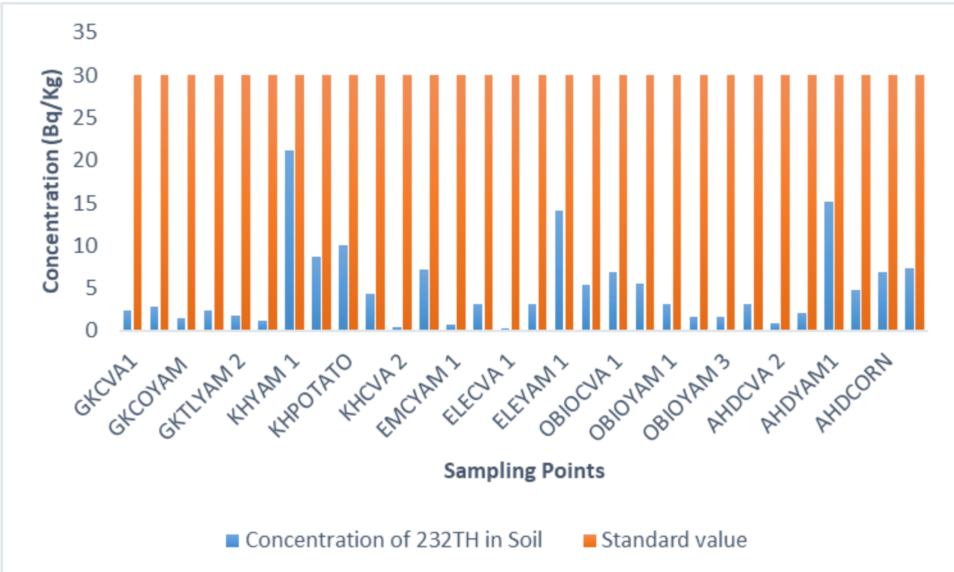

Fig .4: Concentration of ^{234}U in soil with standard

Table 2: Specific Activity Concentration of ^{40}k, ^{238}U and ^{232}Th in Crops Simples from selected Fertilized Farms

S/N	LOCATION		^{40}K (Bq /Kg)	^{234}U (Bq/Kg)	^{232} Th (Bq/Kg)
1	Gokana	CVT1	183.55±11.00	BDL	2.17±0.16
2	,,	CVT2	361.46±25.44	BDL	4.22±0.37
3	,,	CYMT	494.41±32.39	6.85±1.40	1.61±0.15
4	,,	TLYMT1	418.12±29.18	13.21±2.88	1.61±0.61
5	,,	TLYMT2	212.24±15.32	16.58±3.75	0.80±0.07
6	Khana	CON	117.69±9.37	18.47±3.93	4.09±0.36
7	,,	YMT	193.38±14.44	20.35±3.93	0.48±0.05
8	,,	TLY	330.61±24.25	16.18±3.60	0.22±0.02
9	,,	POT	447.60±29.24	10.57±2.31	21.74±1.90
10	,,	CVT1	7.38±0.70	4.44±1.03	21.74±1.90
11	,,	CVT2	248.871±18.18	16.58±3.75	0.80±0.07
12	Emohua	CVT	43.89±29.61	4.92±1.12	4.61±0.43
13	,,	CYMT	74.10±6.78	28.11±5.58	4.41±0.40
14	,,	CYMT2	369.42±24.13	7.57±1.65	5.06±0.43
15	Eleme	CVT1	19.51±1.75	BDL	6.02±0.52
16	,,	CVT2	49.09±4.27	13.12±2.56	4.32±0.38
17	,,	YMT	195.14±14.71	32.79±6.24	2.63±0.25
18	,,	YMT2	293.73±22.01	15.96±3.25	1.33±0.16
19	Obio/Akpo	CVT1	171.34±13.47	26.91±4.82	0.71±0.08
20	,,	CON	205.88±1.64	20.54±3.82	7.30±0.62
21	,,	YMT1	238.74 ±18.15	46.36±8.05	1.27±0.02
22	,,	YMT2	452.66±31.02	BDL	0.88±0.09
23	,,	BYMT3	173.14±10.47	25.91±4.82	0.61±0.08
24	Ahoada	CVT1	204.66±1.14	22.14±3.82	6.40±0.62
25	,,	CVT2	228.64 ±12.15	44.26±8.05	1.77±0.02
26	,,	CVT3	451.33±11.02	26.14±3.05	1.08±0.09
27	,,	CYMT1	418.12±29.18	13.21±2.88	1.61±0.61
28	,,	CYMT2	218.14±12.02	17.28±1.65	2.80±0.07
29	,,	CON	115.19±2.37	17.27±1.93	5.04±0.16
30	,,	TLYMT	412.12±29.18	16.21±2.80	2.61±0.61
	Mean		**218.14±23.28**	**17.28±3.11**	**2.80±0.31**
31	Control 1		89.22±1.32	10.48±3.75	0.40±0.07
32	Control 2		78.69±9.37	0.47±3.93	1.09±0.36

Table 3: Specific Activity Concentration of Transfer Factor of ^{40}k, ^{238}U and ^{232} Th

S/N	Location	Sampling Code	^{40}K (Bq /Kg)	^{234}U (Bq/Kg)	^{232} Th (Bq/Kg)
1	Gokana	CVT1	27.64307	0	0.893004
2	,,	CVT2	40.61124	0	1.523466
3	,,	CYMT	4.636688	0.519333	1.133803
4	,,	TLYM1	3.352201	1.264115	0.665289
5	,,	TLYM2	6.676313	0.710064	0.462428
6	Khana	CON	2.081903	1.138718	3.556522
7	,,	YMT	1.680542	1.43918	0.022642
8	,,	TLYT	6.591108	0	0.025316
9	,,	POT	2.617544	0.451131	2.174
10	,,	CVT1	0.132901	0	5.032407
11	,,	CVT2	9.030116	0	1.95122
12	Emohua	CVT	0.659108	0.260593	0.637621
13	,,	CYMT	0.439528	6.957921	6.488235
14	,,	CYMT2	4.511724	0.846756	1.642857
15	,,	CVT1	0.121067	0	20.75862
16	Eleme	CVT2	0.599536	1.467562	1.402597
17	,,	EYMT	8.684468	2.843886	0.186261
18	,,	YMT2	2.955625	1.04931	0.249064
19	Obio/Akpor	CVT1	2.35908	1.170509	0.103499
20	,,	CON	6.913365	1.121791	1.334552
21	,,	YMT1	7.726214	1.826635	0.415033
22	,,	YMT2	18.28929	0	0.556962
23	,,	YMT3	1.020632	5.151093	0.386076
24	AHOADA	CVT1	2.499511	2.47651	2.077922
25	,,	CVT2	1.393212	10.24537	1.988764
26	,,	AHCVT3	5.233418	3.134293	0.521739
27	,,	CYMT1	17.7395	1.026418	0.105782
28	,,	CYMT2	2.190601	1.3081	0.590717
29	,,	CON	1.400827	0.713931	0.733624
30	,,	TLYMT	14.02723	0.835137	0.352703
	Mean		**6.7939±2.21**	**1.5986±3.07**	**1.9324±2.10**
31	Control 1		22.81841	4.062016	0.377358
32	Control 2		16.56632	0.042457	2.868421
	Control Mean		**19.69237**	**2.052237**	**1.62289**

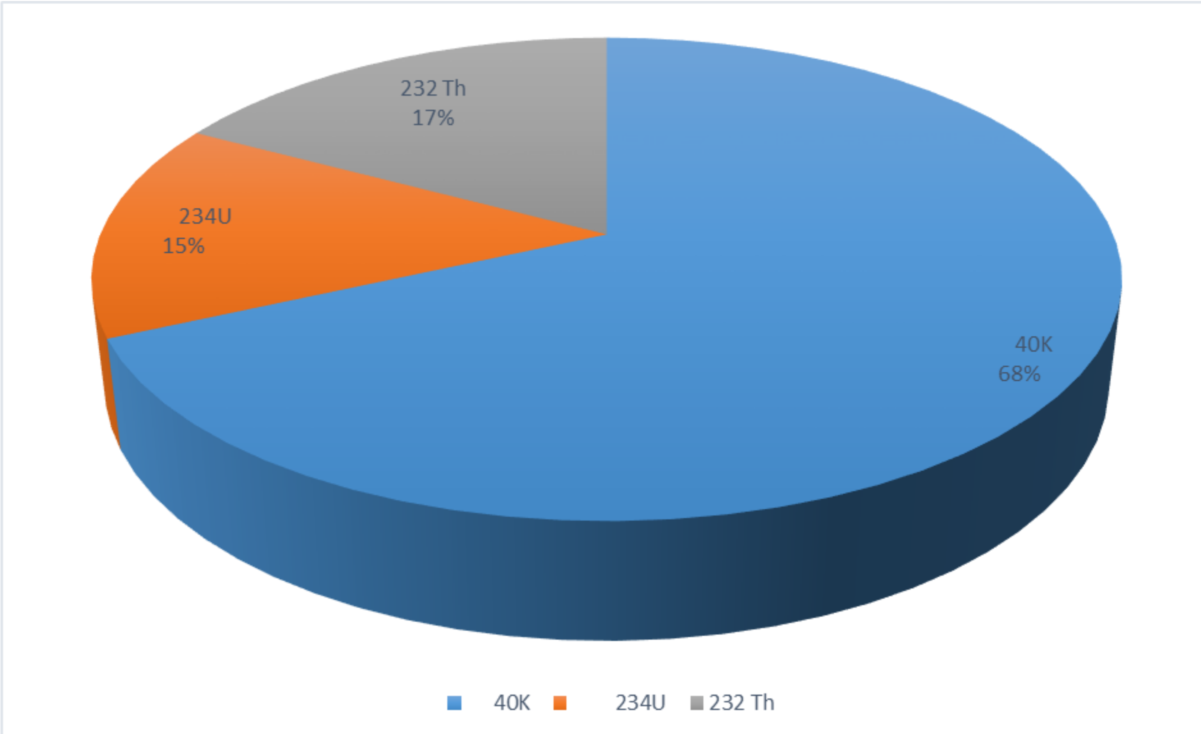

Fig 5 Percentage of Transfer Factor of ^{40}K,^{234}U and^{232} Th

5. Discussion

The transfer factor (TF) obtained varies from 0.121-22.818, 0-10.25, and 0.023-5. 03 Bq/kg for ^{40}k, ^{234}U and ^{232}Th respectively and mean value of 7.60, 1.62 and 1.913 Bq/kg. This variation may be due to differences in organic matter, soil content and soil of type. The higher value of transfer (TF) was obtained in ^{40}k from Gokana Local Government Area. This may be due to long use of nitrogen –Phosphate–potassium (NPK) fertilizers within the farms and also due to the high accumulation of radionuclide in soil which in turn lead to the high uptake by plants within the study area. Fig 5 showed the Percentage of radionuclide Transfer Factor of ^{40}K,^{234}U and ^{232}Th**,** 68%,17%and15% respectively. The lower value of transfer factor (TF) was recorded in ^{234}U and it did not agree with the work [1]. The result shows the opposite of this assumption for example, the average activity concentrate from Gokana cassava two was 8.90 Bqkg^{-1} with a transfer factor of 40.64. The percentage of Radionuclide is shown in Fig.5 and the higher percentage of transfer factor of Radionuclide was obtained in potassium 40 (^{40}K), Thorium 232 (^{232}Th) has the second higher value and Uranium (^{234}U) has the lowest value of transfer factor within the study area and it indicate that the Radionuclide within the fertilized farms are transfer to the tubers due to the application fertilizers during the cultivation period. Several factors may affect the transfer factor such as the plant species, soil pH, types of plant, organic matter content, soil management practice and the methods of application of fertilizers during the cultivation period. The result of transfer factor of the study area is higher than the transfer factors value reported, by [8] potassium (^{40}K) has the highest mean value of transfer factor which properly may be due to its higher accumulation in soil and higher uptake by plant due to the consistent application of NPK fertilizers. Transfer factor varies with location and plant type and it is assumed that plant concentration increases with an increase in soil concentration according transfer factor definition. The transfer factor (TF) results obtained is higher than the value obtained by [16,12,7].

Conclusion

The radionuclide transfer ratio from soil to crops of the selected fertilized farms has been carried out and the results show that higher value of transfer factor was obtained in ^{40}k from Gokana Local Government Area. This high value of ^{40}K may be due to the long use of NPK fertilizers within the selected farmer or due to its high accumulation in soil and the higher uptake by plants within the study area.

The results obtained show that the activity concentration of tuber samples were higher than the activity concentration of cereals samples, this may be due to the direct contact of the tubers with the soil. Also crops like yam, cocoyam cassava etc. spent more time in the fertilized farms than cereal. Higher percentage of transfer factor of Radionuclide was obtained in potassium 40 (^{40}K), Thorium 232 (^{232}Th) has the second higher value and Uranium (^{234}U) has the lowest value of transfer factor within the study area and it indicate that the Radionuclide within the fertilized farms are transferred to the crops.

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