Original Research Article

TRANSFER FACTOR OF RADIONUCLIDES FROM SOIL TO PLANT IN SELECTED DUMP SITE OF OBIO/AKPOR AND IKWERRE LOCAL GOVERNMENT AREAS OF RIVERS STATE

Abstract

Indiscriminate dumping of municipal and industrial wastes in our environment has increased human exposure to hazardous substances which is detrimental to their health. In this research, radionuclide transfer factor was ascertained from crops planted near major dump sites in Rivers State. Samples of food crops and soil near the dumpsites were collected for gamma spectroscopy.The specific activity concentration for crop (cassava) and soil are presented in table 1, 2. Table 3 shows the transfer factor. The average activity concentration of ^{40}K*,* ^{238}U *and* ^{232}Th *in soil are 115.87±17.01 Bqkg*$^{-1}$*, 31.54±7.13 Bqkg*$^{-1}$ *and 18.77±6.02 Bqkg*$^{-1}$*. And the average activity concentration in crop are 403.46±13.06 Bqkg*$^{-1}$*, 9.54±4.02 and 22.24±5.11 respectively for* ^{40}K*,* ^{238}U *and* ^{232}Th*. In soil, all the radionuclide values were all within the world average value and in crop, the values were also within the world average value except for potassium (*^{40}K*) was more prevalent in crop and exceeds the world average value of 400Bqkg*$^{-1}$*. The activity concentration of radionuclides (*^{40}K*,* ^{238}U *and* ^{232}Th*) for transfer factor are 8.187667Bqkg*$^{-1}$*, 0.231667Bqkg*$^{-1}$ *and 2.144333Bqkg*$^{-1}$ *respectively with potassium having the highest mean transfer factor which may be due to its higher accumulation in crop. The maximum distribution of transfer factor in radionuclide is in the order of* $^{40}K>^{238}U>^{232}Th$ *respectively, the average is in order of* $^{40}K>^{238}U>^{232}Th$*. The minimum distribution for all the radionuclide are 0.00.*

Keywords: Transfer Factor, Specific Activity, Dumpsites

Introduction

Our environment and its compartments have been severely contaminated by natural radionuclide, to foster life and render its intrinsic values. Even humans carry naturally occurring radioactive materials within their bodies (Acquah et al., 2013). Natural radioactivity and its corresponding gamma radiation exposure demonstrate geological and geographical dependence. Such materials exist at varying levels in different regions worldwide (Avwiri and Agbalagba, 2007). Primordial isotopes of ^{226} Ra, ^{232}Th and ^{40}k are the main sources of external radiation on earth; (UNSCEAR, 2000). These radionuclides, along with essential nutrients, may be absorbed from the soil via plant roots and transported to other parts of the plant. The presence of radioactivity in the edible parts of crops causes human internal exposure to^{226}Ra and ^{232}Th which are radiotoxic elements, whereas ^{40}K is both radiotoxic and nutritionally important (Gaffer et al., 2013). Natural exposures arise mainly from the primordial radionuclides which are distributed widely and are present in almost all geological materials in the earth's environment. These radionuclides are known as naturally occurring radioactive material 'NORM'. the majority of naturally occurring radionuclide belong to the radionuclides in the ^{238}U and ^{232}Th series, and the single decay radionuclide, ^{40}K, the most common radiation exposure to which all individual are exposed, both in public places and in working environment is the ionizing radiation which arises from the Radionuclides in the earth's environment and the interaction of cosmic rays on the earth's atmosphere (atm). According to NCRP, (1998) National Council on Radiation Protection and Measurements, the most significant source of radiation exposure to man is from the natural radiation in the environment.

There is always a need to have baseline background level information about natural radionuclides and the radiological impact of radionuclides released in the environment, which is usually predicted by mathematical models in which the transfer of radionuclides from soil to the plant is described with the transfer factor (TF). The most commonly encountered radionuclides are ^{238}U, ^{232}Th, their decay products and^{40}K. It is important to understand the behavior of natural radionuclides in the environment (distribution pathways, mobility, transfers, etc.) because the information can be used as a natural analogue for the long-term behavior of materials, processes in developing and testing models, and in obtaining the associated parameter values appropriate for radiological performance assessments (Chen, *et al.*, 2005).

Many studies on food contamination radionuclides in the environment and their transfer or pathway mechanism to plant, animals, and human population have been reported. Considerable efforts are being made by many authors in many parts of the world to measure the activity of radionuclides in the food chain and to estimate the soil-plant transfer.

Interactions between radionuclides and plants are very complicated and depend on many factors such as type and shape of plants, soil characteristics, behavior of radionuclides, climatic conditions, etc.

In many states across the country, waste are usually burnt outdoors and ashes are poorly disposed at dump-site, the process destroys the organic components and causes the oxidation of metals. The ashes from the burnt waste is enriched with metal, which results in pollution of the present environment/Soil. (Ononugbo *et al.*, 2019).

Following the fact that food is one of the most important needs of man and the increasing world population has become a threat to global food security. The need to increase food production therefore arises to ensure food security for the growing world population.

Just like the rest of the world, Nigeria’s population is increasing and there is also the need to increase availability of food by increasing the rate of food production that is free from unnecessary exposure to radiation. Cassava as a tuber is one of the staple food for over one billion (1,000,000,000) people in the developing world, (Ononugbo and Anyalebechi, 2007). In Nigeria, it appears to be the major staple food that matches population growth.

Cassava is a tropical, perennial plant with an dibble root serving as a major source of carbohydrates in human diet as a vegetable and is considered to be toxic in raw form therefore it must be cooked before being consumed (FAO, 2010).Cassava originated from tropical America and was first introduced in Africa in the Congo basin by the Portuguese around 1558. Cassava has been the major source of the production of dry chips, used as animal feed, ethanol production, with more secondary products like textile, soft drinks adhesives etc. starch making which is used in the production of biscuits, bread custard powder, baby food etc. These products are highly commercialized. Generally, Africans depends much on root and tuber crops more than other Continents in feeding its population, it is processed in several forms in Nigeria such as garri (for making eba popular food in Nigeria), fufu, tapioca, (African salad) served with nuts and coconut (Ononugbo*et al.*, 2017).

Material and Methods

Sample Collection

Total of sixty (60) sample (30 soil and 30 cassava) were collected from selected refuse dump sites in Ignatius Ajuru University of Education (IAUE), Port Harcourt in Obio/Akpor Local Government Area, Aluu and Igwuruta in Ikwerre Local Government Area all in Rivers State.

Collection of Soil Sample and Preparation

60 samples of soil were collected from same points as the corresponding crops using a hand trowel, from the refuse dumpsites all in Rivers State, at 20cm depth according to Avwiri (2011). After its collection, the samples were pulverized to powdery form and sieved through a 2mm mesh and air-dried for 3-5 weeks. The sample were weighed to 200g of each soil and packed in special air tight polyethlen plastic containers and closed (tightly) sealed using masking –tape for 28 days to give room for secular equilibrium before gamma counting (Idowu, 2014).

1. **Preparation of Cassava (Crop)**

Total of thirty (30) cassava samples were collected from the three (3) study area (IAUE, Aluu and Igwuruta). The samples were pilled and washed with pipe-borne water to remove the dust and mud content from it. The tubers samples were chopped and sun- dried according to its location and sample point for about three (3) weeks, then pulverized in a powdered form toachieve homogeneity and then filled in an air-tight polyethylene materials for 28 days to achieve secular equilibrium all the samples are in 200g (0.2kg)

Sample Analysis

The transfer Factor (TF) is defined as the ratio of the activity concentration in a plant part (Bqkg^{-1} dry weight) to the activity concentration in soil (Bqkg^{-1} dry weight). It is calculated following a simple model which is also recommended by International Union of Radioecology (IUR) and its standardize root location of 10-20cm in order to deal with the soil depth variability (Avwiri *et al.*, 2007).

$$TF = \frac{A_P B_q kg^{-1}}{A_s B_q kg^{-1}}$$

Where;

Ap = Activity concentration of radionuclide (isotopes) of plant (Bqkg^{-1}dry weight).

As = Activity Concentration of radionuclides (Isotopes) of soil (Bqkg^{-1}dry weight).

Results of Findings

Table 1: Specific Activity Concentration of Radionuclide in Crops Sample

S/N	SAMPLE CODE	^{40}K	^{238}U	^{232}Th
1	ALUU CAS 01	564.30±44.75	BDL	13.20 ± 1.40
2	ALUU CAS 02	594.33±47.13	BDL	1.20 ± 0.12
3	ALUU CAS 03	432.62±34.50	BDL	47.99 ± 4.92
4	ALUU CAS 04	523.23±41.80	BDL	34.32 ± 3.54
5	ALUU CAS 05	680.22±54.11	BDL	36.40 ± 3.77

6	ALUU CAS 06	839.40±66.72	BDL	3.49 ± 0.36
7	ALUU CAS 07	326.90±26.40	BDL	18.32 ± 1.92
8	ALUU CAS 08	311.02±21.9	27.23±1.23	28.50± 2.32
9	ALUU CAS 09	452.01± 21.09	25.33± 3.20	23.15±0.34
10	ALUU CAS 10	253.24±20.12	43.22±2.71	22.51±2.18
11	IAUE CAS 01	217.27±23.15	28.45±2.36	7.26±0.29
12	IAUE CAS 02	207.28±2.35	40.12±2.34	8.91±0.37
13	IAUE CAS 03	222.31±17.97	BDL	18.18 ± 1.89
14	IAUE CAS 04	210.20±16.94	BDL	26.13 ± 2.71
15	IAUE CAS 05	752.10±59.85	BDL	16.93 ± 1.75
16	IAUE CAS 06	276.22±22.50	16.16±3.80	8.10 ± 0.83
17	IAUE CAS 07	348.31±28.20	BDL	24.84 ± 2.60
18	IAUE CAS 08	399.90±32.21	BDL	21.13 ± 2.20
19	IAUE CAS 09	218.99±18.03	6.97±1.64	47.99 ± 4.95
20	IAUE CAS 10	210.72±12.10	2.34±0.25	28.22±1.8
21	IGU CAS 01	640.41±50.80	BDL	9.66 ± 1.01
22	IGU CAS 02	543.20±21.03	47.29±2.88	12.32±2.08
23	IGU CAS 03	547.60±43.76	BDL	10.70 ± 1.11
24	IGU CAS 04	310.20±25.10	35.63 ± 8.40	12.91 ± 1.34
25	IGU CAS 05	429.81±34.60	6.35 ± 1.52	44.90 ± 4.60
26	IGU CAS 06	640.41±50.80	BDL	9.66 ± 1.01
27	IGU CAS 07	187.63±15.32	BDL	34.9 ± 3.60
28	IGU CAS 08	25.33±2.12	BDL	11.32 ± 1.20
29	IGU CAS 09	436.82±35.24	BDL	54.84 ± 5.70
30	IGU CAS 10	302.01±23.19	7.28±2.16	32.42±3.18
	Average	**403.46±13.06**	**9.54±4.02**	**22.24±5.11**

Table 2: Specific Activity Concentration of Radionuclides in Soil Samples

S/N	**SAMPLE CODE**	**^{40}K**	**^{238}U**	**^{232}Th**
1	ALUU SOIL 01	BDL	2.92 ± 0.70	4.32 ± 0.43
2	ALUU SOIL 02	32.80±2.53	9.82 ± 2.30	2.90 ± 0.30
3	ALUU SOIL 03	50.32±3.81	9.80 ± 2.10	7.50 ± 0.73
4	ALUU SOIL 04	291.30±22.04	8.40 ± 1.80	4.32 ± 0.42
5	ALUU SOIL 05	27.44±3.05	50.04±14.10	12.71 ± 1.55
6	ALUU SOIL 06	64.50±6.82	19.37±5.51	77.73 ± 8.43
7	ALUU SOIL 07	127.88±12.81	13.52±3.78	8.00 ± 1.01

8	ALUU SOIL 08	129.92±13.60	28.15±7.66	62.76 ± 7.08
9	ALUU SOIL 09	272.86±2183	BDL	29.74 ± 3.06
10	ALUU SOIL 10	89.35±2.66	43.22±3.26	37.22±6.15
11	IAEU SOIL 01	19.01±2.13	29.65±8.50	53.72 ± 6.11
12	IAEU SOIL 02	224.60±17.30	BDL	2.92 ± 0.30
13	IAEU SOIL 03	283.10±21.41	11.70 ±2.51	4.10 ±0.40
14	IAUE SOIL 04	81.50±8.33	53.40 ± 14.23	21.64 ± 2.64
15	IAEU SOIL 05	56.40±6.10	84.97±23.98	2.73 ±0.40
16	IAEU SOIL 06	8.17±0.92	61.50±16.20	13.40±1.65
17	IAEU SOIL 07	160.90±16.26	62.30±17.50	13.40 ± 1.62
18	IAEU SOIL 08	37.25±4.20	62.44±16.54	33.10 ± 3.83
19	IAUE SOIL 09	147.83±15.65	28.93±7.73	50.13 ± 5.78
20	IAEU SOIL 10	21.05±2.23	81.05±21.31	14.65 ± 1.80
21	IGU SOIL 01	60.10±4.55	BDL	7.72 ± 0.80
22	IGU SOIL 02	533.20±41.10	BDL	6.10 ± 0.60
23	IGU SOIL 03	256.70±19.60	8.20±1.90	9.70 ± 1.0
24	IGU SOIL 04	28.73±2.22	9.52±2.2	3.50 ± 0.34
25	IGU SOIL 05	124.60±9.61	9.40±2.22	5.0 ± 0.50
26	IGU SOIL 06	80.96±8.10	71.23 ± 19.12	15.91 ± 1.96
27	IGU SOIL 07	58.62±4.93	1.60 ± 0.37	19.60 ±2.03
28	IGU SOIL 08	96.30±10.10	68.98 ± 18.70	19.90 ± 2.42
29	IGU SOIL 09	53.70±5.54	51.11±13.50	7.70 ± 0.95
30	IGU SOIL 10	57.30±3.44	65.23±2.77	11.21±1.22
	Average	**115.87±17.01**	**31.54±7.13**	**18.77±6.02**
	ICRP	**400.00**	**30.00**	**35.00**

Table 3: Transfer Factor

S/No	Sample	^{40}K	^{234}U	^{232}Th
1	ALUU 01	0.00	0.00	3.00
2	ALUU 02	18.11	0.00	0.41
3	ALUU 03	8.59	0.00	6.31
4	ALUU 04	1.79	0.00	7.94
5	ALUU 05	24.78	0.00	2.86
6	ALUU 06	13.03	0.00	0.04
7	ALUU 07	2.55	0.00	0.00
8	ALUU 08	2.00	0.96	0.45
9	ALUU 09	32.0	0.00	0.77

10	ALUU 10	2.83	0.00	0.60
11	IAUE 01	11.42	0.95	0.13
12	IAUE 02	0.92	0.00	3.05
13	IAUE 03	0.72	0.00	4.43
14	IAUE 04	2.59	0.00	1.20
15	IAUE 05	13.33	0.00	6.20
16	IAUE 06	33.8	0.26	0.60
17	IAUE 07	2.16	0.00	1.85
18	IAUE 08	10.73	0.00	0.63
19	IAUE 09	1.48	0.24	0.95
20	IAUE 10	10.01	0.02	1.92
21	IGU 01	10.65	0.00	1.25
22	IGU 02	1.01	0.00	2.01
23	IGU 03	2.13	0.00	1.10
24	IGU 04	10.79	3.74	3.68
25	IGU 05	3.44	0.67	0.00
26	IGU 06	7.91	0.00	0.60
27	IGU 07	3.20	0.00	1.78
28	IGU 08	0.26	0.00	0.56
29	IGU 09	8.13	0.00	7.12
30	IGU 10	5.27	0.11	2.89
31	**Minimum**	**0.00**	**0.00**	**0.00**
32	**Maximum**	**33.8**	**3.74**	**7.94**
33	**Average**	**8.187667**	**0.231667**	**2.144333**
34	**Sum**	**245.63**	**6.95**	**64.33**

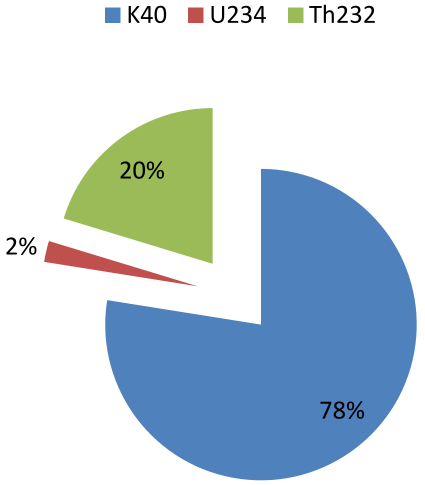

Figure 1: Percentage Contribution of Radionuclide in Transfer Factor

Discussion of Results

Results from Specific Activity Concentration of Radionuclides (Bqkg^{-1}) in the Three Refuse Dumpsites

The result for the concentration of specific activity of radionuclide of potassium (^{40}K), Uranium (^{238}U) and Thorium (^{232}Th) in cassava tuber samples are presented in table 1. The activity concentration due potassium (^{40}K) ranged from 25.33±2.12 to 839.40±66.72 with its mean value OF 9.54±4.02 Bkkg^{-1} and the concentration of Thorium (^{232}Th) varies between 1.20±0.12 to 47.99±4.95 with its mean value of 22.24±5.11 Bqkg^{-1} respectively. The result obtained is less than the one reported by Ononugbo et al., (2019). The result for the concentration of specific activity of radionuclide of potassium (^{40}K), Uranium (U^{238}) and Thorium (^{232}Th) in soil samples are presented in Table 2. The activity concentration due potassium (^{40}K) ranged from BDL to 533.20±4.55 Bqkg^{-1} with its mean value of 115.87±17.01 Bqkg^{-1}. When compared with the world standard, it is below its permissible limit of 400.00 Bqkg^{-1}. The concentration of Uranium (^{238}U) in soil ranged from BDL to 68.98±18.70 with its mean value of 31.54±7.13 Bqkg^{-1} it shows increase in the level of Uranium (^{238}U) which could be due to indiscriminate dumping of different types of waste, but may not cause immediate health effect. Concentration of Thorium (^{232}Th) in soil sample lies between 2.73±0.40 to 77.73±8.43 with mean value of 18.77±6.02 Bqkg^{-1} respectively, which is below the permissible limits of 35.00 Bqkg^{-1}, indicating that there will be no potential radiological risk. The results obtained, is above that related by Avwiri and Agbalagba (2014).

Transfer Factor

The Transfer Factor (TF) is the ration that depicts the quantity of radionuclides expected to enter the crop from soil (Rodrigueze *et. al.,* 2002).

The transfer factors are recorded in table 3 for potassium uranium and thorium, the transfer factor ranged from 0.00-33.809, 0800-3.742 and 0.044-7.944 respectively with its means concentration of 7.194, 0.243 and 2.527 respectively. These values are all above the recommended IAEA value for 0.04 and 0.05 for potassium, uranium and thorium respectively. This implies that the crop (cassava) may be radiologically harmful to human health. The high value of transfer factor for potassium may be due to its adaptability of plant to environmental measures (Pulhani *et. al.,* 2005). It may also be enhanced by the un-necessary disposal of refuse of different kind. The range of radionuclide due transfer factor are in other of ^{40}K,<^{232}Th <^{238}U. the rate at which they are transferred to cassava is still moderate. From the definition of transfer factor, it is assumed that the plant concentration increases with increase soil concentration (Tchokossa *et. al.*, 2013). The result in this work shows the opposite of this assumption. The activity concentration of ^{40}K in soil sample IGU Soil 04 is 28.73±2.22 with transfer factor of 1.018. The transfer factor result of this work buttresses the fact that transfer factors are not linearly related to soil concentration (Martinez et al., 1997). Many factors affect the transfer factor such as physiochemical characteristics of radioisotopes and soil, plant species, soil pH and fertility, plant type, organic matter content and soil management practices. Comparing the result with available literatures, the result in this work is higher than the values obtained by Tchokossa et al., (2013), Avwiri *et al.*, (2013), and Ilemona et al., (2016). This could be due to difference in soil properties indiscriminate dumping of different class/types of refuse around the farmland and climatic conditions of the area (IAEA, 2010).

Figure 1. shows the percentage contribution of radionuclide in transfer factor, where potassium was recorded 78%, Uranium 2% and Thorium 20% respectively.

Conclusion

The naturally radioactivity levels has been measured in cultivated soil and the most stable crop (cassava) from selected refuse-dump site in Obio/Akpor and Ikwerre Local Government Area of Rivers State in Nigeria. The activity concentration of transfer factor for ^{40}k, ^{238}U ^{232}Th estimated in the transfer factor are 8.187, 0.231 and 2.144 respectively. The mean concentration of all the radioisotopes in the crop may not cause instant health hazard to the public but there may be a long term accumulative effect following present dose intake from the consumption of the crop (cassava).

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