NIGERIA JOURNAL OF PURE AND APPLIED PHYSICS

**Nigeria Journal of Pure and Applied Physics, Vol. 7, No. 1, pages 7–12, 2017**

# TRANSFER FACTOR OF RADIONUCLIDES FROM SOIL-TO-PALM OIL PRODUCED FROM ELERE PALM TREE PLANTATION NEAR IBADAN OYO STATE, NIGERIA

**S. K. Alausa†, Kola Odunaike and I. A. Adeniji**

Department of Physics, Olabisi Onabanjo University, Ago-Iwoye, Nigeria

†Corresponding Author's Email: alausakunle@yahoo.com

**Abstract:** The migration of contaminants including radionuclides from soil-to-plant system is usually predicted by mathematical models commonly employed in a soil-to-plant transfer factor for activity concentration. Local palm trees found mostly in Nigeria are very tall and their fruits are used for production of red palm oil. Ibadan and its environs including Elere are underlain by crystalline basement complex which is known to be rich in natural radionuclides. Hence enhanced radioactivity and soil-to-plant transfer factor influenced by physical-chemical form of the radionuclides in the soil and types of plant could be obtained. The study is aimed at determining the radioactivity levels of $^{40}$K, $^{238}$U and $^{232}$Th in the soil and palm oil; and calculating the soil to palm oil transfer factor. A total number of 20 palm trees were randomly selected in the study areas. From each palm tree, bunches of palm fruits were collected to prepare palm oil and the soil samples at the spot of the tree were also collected. The activity concentration of the natural radionuclides were determined using a single crystal 0.51cm x 0.51cmNaI (Tl) detector coupled through a Hamamatsa (R1306NSV3068) photomultiplier tube to a Multichannel Analyser, MCA (2100R:01). The activity concentrations of $^{40}$K, $^{238}$U and $^{232}$Th in palm oil ranged from 50.48 Bqkg$^{-1}$ to 112.16 Bqkg$^{-1}$; 6.35 Bqkg$^{-1}$to 12.80 Bqkg$^{-1}$and 6.08 Bqkg$^{-1}$to 10.13 Bqkg$^{-1}$ respectively. The activity concentrations of $^{40}$K, $^{232}$U and $^{232}$Th in the soil samples ranged from 412.43 Bqkg$^{-1}$to 672.16 Bqkg$^{-1}$; 10.25 Bqkg$^{-1}$to17.43 Bqkg$^{-1}$and 8.12 Bqkg$^{-1}$to 12.48 Bqkg$^{-1}$respectively. The mean transfer factors were 0.17±0.02, 0.27±0.06 and 0.28±0.02 for 40K, 238U and 232Th respectively. The $^{40}$K, $^{238}$U and $^{232}$Th radioactivity levels in the soil are comparable to the world average values of 420Bqkg$^{-1}$, 32 Bqkg$^{-1}$and 40 Bqkg$^{-1}$respectively. The transfer factors indicated that about 17%, 27% and 28% of $^{40}$K, $^{238}$U and $^{232}$Th respectively are transferred from soil to the palm.

**Keywords:** radionuclide, transfer factor, mathematical model, palm oil, Ibadan

## 1. INTRODUCTION

Human environment is filled with both natural and artificial radionuclides that continuously disintegrate to release nuclear particles (α- and β-particles) together with neutral and lighter particles (neutrinos). The internal and external radiation exposure of human is the consequence of the release of these nuclear particles into the environment. The natural radionuclides, $^{232}$Th and $^{238}$U including their decay products and non-series $^{40}$K are distributed by the geological and geochemical processes in the soils that originated from the earth crust [1]. About 96.1% of the total radiation dose received annually by the world population which comes from natural background radiation source is huge compare to radiation dose from man-made sources that accounts for 3.9% [2]. The natural sources are from terrestrial (primordial) and extra-terrestrial (cosmic) origins. The internal exposure of human is mainly associated with food consumption [3].

Primordial radionuclides in the soil are transported to food crops through plant-root uptake. The uptake of radionuclides from soil to plant is characterized by the transfer factor [4]. The transfer of radionuclides from the soil to plant system referred to as transfer factor (TF) is an assessment model commonly utilized in a soil-plant activity concentration ratio. Various studies on natural radionuclides transfer or pathway mechanism to plant have been reported in the literatures [5–7]. Till today the transfer factor remains the useful tool to scientists for predicting the radionuclide concentration in agricultural crops and estimating dose impact to human as reported by IAEA [8].

The soil-to-plant transfer factor of long-lived radionuclides is complex as it depends on some factors such as soil characteristics, climatic conditions, type of plants, part of the plant concerned, physical-chemical form of the radionuclides and the interfering element [9]. The presence of calcium and potassium in soil affect the uptake of uranium, thorium and radium content by plant and the clays of alluvial soil, which trap potassium in its crystal lattice, and the contents of phosphate that forms insoluble compounds reduce radionuclide availability to plants [3].

Palm trees originated from tropical Africa and spread to other part of the world including Asia and South America. Palm trees (*Elaesis Guineensis*) are common species found in West Africa and grown in the wet rain forests and savanna belt predominantly domesticated in south western and south eastern of Nigeria. These trees also survive in the wet parts of North Central of Nigeria including Southern Kaduna, Kogi, Kwara, Benue, Niger, Plateau, Taraba, Nasarawa and part of Federal Capital Territory. The trees need warm temperatures, sunshine and plenty of rainfall to maximize production of oil. Palm oil is one of the world's most produced and consumed oils. The oil is used in a wide variety of food, cosmetic and hygiene products, and can be used as source for bio-fuel or biodiesel [10].

The study area (Elere palm oil plantation) situated in Ido Local Government area of Oyo State has geological setting (crystalline basement complex) like Abeokuta which has been reported as high background radiation area [11]. Oyo State is underlain by crystalline basement complex, comprising migmatite-gneiss complex (quartzite, gneissic rocks); low to medium grade meta-sediments (quartz schist and mica schist) and the Pan African Granitoids (older granites) [12, 13].

Although Chen et. al., [3] reported that the accumulation of radionuclides in different plant tissues system differ and decreases from the root to the crop. The transfer of radionuclides from soil to the tall palm trees (*Elaesis Guineensis*) grown in such high background radiation area may be elevated. Therefore, it is important to investigate the transfer factor of radionuclides from soil to the palm oil produced and consumed by the populace from the area and exported to other part of the country for consumption.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The study was carried out at the Elere Oil Plantation/Mill in Ido Local Government Area of Oyo State, Nigeria. The oil palm plantation is located very close to the border between Abeokuta in Ogun State and Ibadan in Oyo State. The land mass area of the plantation is 12,943.50m$^2$. About 45,000 tons of palm fruits are harvested annually; 40,000 tons of palm oil and 1,500 tons of palm kernels are produced annually in the plantation mill. The palm oil mill provides jobs for about three thousand workers and about two thousand peasant farmers are also farming and living around the mill.

The coordinates (taken with a Global Positioning System (GPS)) of the sampling points in the plantation are shown in Table 1 and the topographical map of the area is shown in Figure 1. The study area enjoys tropical climate marked by alternating raining and dry season with annual temperature ranging from 35ºC to 42ºC. The mean annual rainfall of the area is 1350mm with high relative humidity of about 70%.

### 2.2 Sampling

Twenty palm trees were randomly selected from Elere palm tree plantation for the study. The GPS at the sampling points were taken with a GPS. A bunch of palm fruits was harvested from each tree by hand with the aid of scythe (harvesting tool) and ripe palm fruits were removed from the bunch and packed in polythene bags.

To measure the natural radioactivity in the soil samples including the organic and inorganic particles, soil from the sampling point were collected with hand auger to a depth of 15cm and surface area of about 250 sq. mm from ten different points round each palm tree. Thereafter, the soil samples collected were thoroughly mixed together to make a representative sample. The samples from the palm trees were carefully packed in polythene bags and taken to laboratory for preparation and spectrometric analysis.

**Table 1:** Coordinates of the sampling locations

| Location | Latitude (N) | Longitude (E) | Elevation |
|---|---|---|---|
| Gps1 | 007$^0$ 25’ 18.3’’ | 003$^0$ 29’ 30.0’’ | 133.7m |
| Gps2 | 007$^0$ 25’ 18.7’’ | 003$^0$ 29’ 03.2’’ | 115.8m |
| Gps3 | 007$^0$ 25’ 19.7’’ | 003$^0$ 29’ 02.7’’ | 119.5m |
| Gps4 | 007$^0$ 25’ 20.1’’ | 003$^0$ 29’ 02.6’’ | 111.9m |
| Gps5 | 007$^0$ 25 20.5 | 003$^0$ 29’ 02.3’’ | 110.8m |
| Gps6 | 007$^0$ 25’ 20.7’’ | 003$^0$ 29’ 01.3’’ | 107.7m |
| Gps7 | 007$^0$ 25’ 20.5’’ | 003$^0$ 29’ 00.8’’ | 105.1m |
| Gps8 | 007$^0$ 25’ 20.8’’ | 003$^0$ 29’ 00.4’’ | 104.9m |
| Gps9 | 007$^0$ 25’ 20.6’’ | 003$^0$ 29’ 00.2’’ | 107.3m |
| Gp10 | 007$^0$ 25’ 20.1’’ | 003$^0$ 29’ 00.0’’ | 106.1m |
| Gps11 | 007$^0$ 25’ 19.9’’ | 003$^0$ 29’ 00.5’’ | 104.4m |
| Gps12 | 007$^0$ 25’ 19.8’’ | 003$^0$ 29’ 00.7’’ | 104.5m |
| Gps13 | 007$^0$ 25’ 19.6’’ | 003$^0$ 29’ 01.1’’ | 104.1m |
| Gps14 | 007$^0$ 25’ 19.6’’ | 003$^0$ 29’ 01.2’’ | 99.1m |
| Gps15 | 007$^0$ 25’ 19.9’’ | 003$^0$ 29’ 01.3’’ | 101.3m |
| Gps16 | 007$^0$ 25’ 19.8’’ | 003$^0$ 29’ 01.6’’ | 109.3m |
| Gps17 | 007$^0$ 25’ 19.7’’ | 003$^0$ 29’ 01.7’’ | 102.9m |
| Gps18 | 007$^0$ 25’ 18.8’’ | 003$^0$ 29’ 01.9’’ | 119.3m |
| Gps19 | 007$^0$ 25’ 18.8’’ | 003$^0$ 29’ 02.1’’ | 104.9m |
| Gps20 | 007$^0$ 25’ 18.6’’ | 003$^0$ 29’ 02.1’’ | 103.8m |

### 2.3 Sample Preparation

The palm oil fruits from each tree were sterilized by cooking with steam for about 90-120minutes thereby making the lipase enzyme inactive, fruits softer, nut/pulp separation easier and coagulation of proteins. The process of digestion followed for 30minutes at 100ºC to break oily cells, in order to make oil extraction easier.

The digested mash was mechanically pressed to squeeze oil out of the mixture of fibre, nuts, oil and moisture. The extracted palm oil from each tree was filtered to remove any particulate matters and 200gm was poured into a clean transparent plastic container and sealed for 4 weeks to allow $^{222}$Rn and its short-lived daughters to reach secular equilibrium before spectrometric analysis.

The soil samples were oven dried at a temperature of about 110$^0$C until a constant mass was attained. The samples were then ground and sieved with a mesh of a 2.0mm size. 200gm of the prepared soil samples were later transferred to clean transparent plastic containers of uniform size and sealed for 4 weeks to allow $^{222}$Rn and its short-lived daughters to reach secular equilibrium before spectrometric analysis.

### 2.4 Radioactivity Determination

The radioactivity level was determined using a well calibrated NaI (TI) and well shielded detector couple to a computer resident quantum MCA2100R:1 Multichannel analyzer. Each sample was placed vertically in the detector and counted for 10hours (36,000 seconds). The 1460KeV gamma-radiation of $^{40}$K was used to determine the concentration of $^{40}$K in the sample. The gamma transition energy of 1764.5KeV $^{214}$Bi was used to determine the concentration of $^{238}$U while the gamma transition energy of 2614KeV $^{208}$TI was used to determine the concentration of $^{232}$Th while $^{137}$Cs was detected by its 661.6KeV gamma transition.

The detector does not require any internal PC interface slot or special memory reservations. The MCA 2100R:1 includes Quantum MCA software for qualitative analysis. The MCA 2100R:1 performs an automatic adjustment of the detector bias and amplifier gain. All calibration functions were made through the software. The detector has an energy resolution (FWHM) of about 6.2% of 0.662MeV ($^{137}$Cs) which is considered enough to distinguish the gamma ray energies of interest in the present study. Equation 1 shows the expression for determination of activity concentration [14].

$$C\left(\frac{Bq}{kg}\right) = \frac{c_n}{\varepsilon I_\gamma m_s} \qquad (1)$$

where C is the activity concentration of the radionuclides in the sample; $C_n$ is the count rate under the photo peak; ε is the detector efficiency at the specific γ-ray energy; $I_\gamma$ is the absolute transition probability of specific γ-ray and $m_s$ is the mass of the sample (Kg).

## 3. RESULTS AND DISCUSSION

### 3.1Activity concentration in soil

The values of activity concentrations of radionuclides, $^{40}$K $^{238}$U and $^{232}$Th in the soil from the palm plantation are presented in Table 2. The activity concentration of $^{40}$K was very high compare to the corresponding $^{238}$U and $^{232}$Th in the entire soil samples examined. This has been the usual trend in the radioactivity of different matrices and similar results have been observed in various other studies [2, 15, 16].

The highest $^{40}$K activity concentration value of 672.16±37.91 Bqkg$^{-1}$ was measured at location GPS15 while the least value of 412.31±45.07 Bqkg$^{-1}$ was obtained at location GPS 5 with mean value of 537.3±76.51Bqkg$^{-1}$. The highest $^{238}$U activity concentration of 17.43±3.19Bqkg$^{-1}$ was obtained at GPS1 while the least value of 10.25±3.90Bqkg$^{-1}$ was recorded at GPS14 and the mean value was 12.93±2.28Bqkg$^{-1}$. The highest $^{323}$Th activity concentration

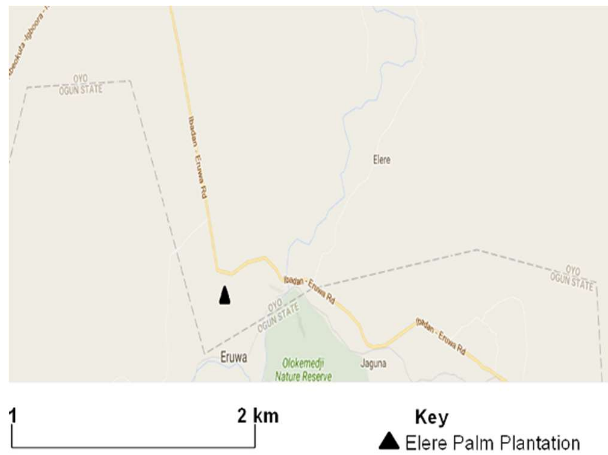


Fig. 1. A topographical map showing the sampling location

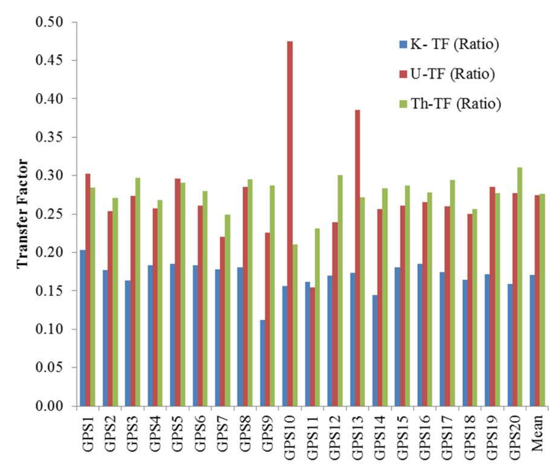


Fig. 2. Bar chart for the soil to radionuclide transfer factor

value of 12.48±2.25Bqkg$^{-1}$ as recorded at location GPS2while the least value of 8.12±1.38Bqkg$^{-1}$ was obtained at location GPS 7 with mean value of 10.00±1.15Bqkg$^{-1}$.

These results showed that the mean activity concentration of $^{40}$K was higher than the world average of 420Bqkg$^{-1}$ and the mean activity concentrations of $^{238}$U and $^{232}$Th were lower than the world values of 32 Bqkg$^{-1}$ and 40 Bqkg$^{-1}$ respectively.

### 3.2 Activity concentration in palm oil

The activity concentrations of $^{40}K$, $^{238}U$ and $^{232}Th$ in the palm oil are presented in Table 3. It is observed that the radioactivity levels measured in the palm oil were low compare to the values measured in the soil from the same location. The activity concentration of $^{40}K$ in the palm oil ranged from 50.48 $Bqkg^{-1}$ to 112.16 $Bqkg^{-1}$ with the mean value of 91.22±14.22$Bqkg^{-1}$. The activity concentrations of $^{238}U$ ranged from 6.35$Bqkg^{-1}$ (GPS11) to 17.43$Bqkg^{-1}$(GPS10) with the mean value of 9.96±2.56$Bqkg^{-1}$. $^{232}Th$ activity concentration ranged from 6.08$Bqkg^{-1}$ (GPS7) to 10.13 $Bqkg^{-1}$ (GPS2) and the mean value was 8.01±1.20$Bqkg^{-1}$.

**Table 2:** Activity concentrations in the soil from Elere palm plantation

| Sampling point | $^{40}K$ ($Bqkg^{-1}$) | $^{238}U$ ($Bqkg^{-1}$) | $^{232}Th$ ($^{228}Ra$) ($Bqkg^{-1}$) |
|---|---|---|---|
| GPS1 | 421.43 ± 38.00 | 42.29 ± 3.19 | 33.09 ± 5.16 |
| GPS2 | 511.18 ± 15.75 | 33.75 ± 3.99 | 37.44 ± 2.25 |
| GPS3 | 612.16 ± 10.01 | 38.82 ± 3.01 | 33.39 ± 2.08 |
| GPS4 | 520.02 ± 30.16 | 34.83 ± 6.40 | 30.69 ± 2.13 |
| GPS5 | 412±31 ± 45.07 | 26.09 ± 4.95 | 24.59 ± 3.30 |
| GPS6 | 612.32 ± 30.10 | 46.05 ± 1.01 | 30.09± 3.24 |
| GPS7 | 525.22 ± 41.03 | 41.91 ± 3.57 | 24.36± 1.38 |
| GPS8 | 621.14 ± 25.86 | 32.19± 4.20 | 30.90 ± 2.41 |
| GPS9 | 450.41 ± 19.28 | 35.28 ± 5.28 | 21.54 ± 3.34 |
| GPS10 | 521.32 ± 27.41 | 36.72± 3.75 | 33.42± 4.02 |
| GPS11 | 610.20 ± 12.22 | 41.15 ± 5.19 | 30.39 ± 1.19 |
| GPS12 | 535.61 ± 12.15 | 32.40 ± 2.37 | 31.26 ± 2.33 |
| GPS13 | 457.43±23.16 | 31.40±2.71 | 30.99±2.10 |
| GPS14 | 497.38±27.30 | 48.87±3.90 | 24.39±1.37 |
| GPS15 | 672.16±37.91 | 30.75±1.76 | 25.44±2.75 |
| GPS16 | 545.22±21.82 | 35.10±3.50 | 25.86±1.89 |
| GPS17 | 467.31±17.67 | 34.53±2.83 | 27.96±2.31 |
| GPS18 | 642.61±19.73 | 33.35±5.12 | 27.75±3.13 |
| GPS19 | 497.52±24.11 | 42.75±3.17 | 29.34±2.53 |
| GPS20 | 613.35±31.86 | 32.85±4.10 | 28.14±3.32 |
| Mean±δ | 537.3±76.51 | 36.55±5.70 | 29.05±3.68 |

The much higher activity concentration of $^{40}K$ radionuclide in the palm oil was attributed to wide distribution of potassium elements (containing $^{40}K$) in nature and high absorption rates as it is significant in plants' growth [17, 18]. The mean activity concentration of $^{238}U$ ($^{226}Ra$) was slightly higher than $^{232}Th$ and this is attributed to high solubility of the radionuclide that may lead to high uptake or absorption characteristics [19].

Jibiri et. al., [20] reported that the radionuclides in food crop reduced when cooked. Therefore, cooking the palm fruits to extract palm oil may have altered the radioactivity level in the oil. In addition, the activity concentration of the water used in the palm oil processing may contain contaminants including radionuclide and hence increase the radioactivity in the palm oil.

### 3.3 Soil to palm oil transfer factor

The transfer of elements including radionuclides from soil to plant referred to as transfer factor can be used as an index for the accumulation of trace elements/radionuclides by plants. Transfer factor (TF) which is defined as the ratios of specific activities in plant to soil can be used to estimate the transportation of radionuclides through the food chain. The soil to plant transfer factor are influence by factors including soil characteristics, climatic conditions, type of plants, physical-chemical form of the radionuclides and the interfering element [21]. For example, the availability of calcium and potassium in the soil will affect the uptake of uranium, thorium and radium radionuclides into the plant

**Table 4:** Soil to palm oil radionuclide transfer factor

| Soil | K (ratio) | U (ratio) | Th(ratio) |
|---|---|---|---|
| GPS1 | 0.20 | 0.30 | 0.28 |
| GPS2 | 0.18 | 0.25 | 0.27 |
| GPS3 | 0.16 | 0.27 | 0.30 |
| GPS4 | 0.18 | 0.26 | 0.27 |
| GPS5 | 0.19 | 0.30 | 0.29 |
| GPS6 | 0.18 | 0.26 | 0.28 |
| GPS7 | 0.18 | 0.22 | 0.25 |
| GPS8 | 0.18 | 0.29 | 0.30 |
| GPS9 | 0.11 | 0.23 | 0.29 |
| GPS10 | 0.16 | 0.47 | 0.21 |
| GPS11 | 0.16 | 0.15 | 0.23 |
| GPS12 | 0.17 | 0.24 | 0.30 |
| GPS13 | 0.17 | 0.39 | 0.27 |
| GPS14 | 0.14 | 0.26 | 0.28 |
| GPS15 | 0.18 | 0.26 | 0.29 |
| GPS16 | 0.19 | 0.27 | 0.28 |
| GPS17 | 0.17 | 0.26 | 0.29 |
| GPS18 | 0.16 | 0.25 | 0.26 |
| GPS19 | 0.17 | 0.29 | 0.28 |
| GPS20 | 0.16 | 0.28 | 0.31 |
| Mean | 0.17±0.02 | 0.27±0.06 | 0.28±0.02 |

[9]. Clays of alluvial soil traps potassium in its crystal lattice, and the contents of phosphate that forms insoluble compounds with thorium, have been observed to reduce radionuclide availability to plants [3, 5, 6]

According to Gaffar et al., [7] the transfer factor (TF) model is given by:

$$TF = \frac{A_F}{A_S} \quad (2)$$

where $A_F$ is the activity concentration of radionuclides in plant/food crop and $A_S$ is the activity concentration of radionuclides in soil.

Using equation 2, the soil-to-palm oil transfer factor of radionuclides ($^{40}$K $^{238}$U and $^{232}$Th) were determined and presented in Table 4. The mean transfer factors obtained in the study were 0.17±0.02, 0.27±0.06 and 0.28±0.02 for $^{40}$K $^{238}$U and $^{232}$Th respectively. The results indicated transfer factors of 17% for $^{40}$K, 27% for $^{238}$Uand 28% for $^{232}$Th.

Figure 2 showed the bar chart of transfer factors for the radionuclides at different sampling points. GPS1indicated the highest value for $^{40}$K. The values of 1.63, 0.40 and 0.39 for soil-vegetable transfer factor of $^{40}$K$^{226}$Ra and $^{232}$Th respectively by Gaffa et. al., [7] were higher than the values obtained for $^{40}$K $^{238}$U and $^{232}$Th in the study.

Although the palm trees are very tall but have fibrous roots like grass, the transfer factors obtained in the study were higher than 0.27 for $^{40}$K, 0.056 for $^{226}$Ra and 0.09 for $^{232}$Th [9] in elephant grass. The transfer factors of $^{238}$U and $^{232}$Th obtained in the study were higher than 0.23±0.13 and 0.20±0.08 respectively and the transfer factor of $^{40}$K was lower than 0.38±0.14 reported for elephant grass [22].

## 5. Conclusion

Despite The activity concentrations of $^{40}$K, $^{238}$U and $^{232}$Th in palm oil and farm soil samples from Elere Palm Tree Plantation have been measured. The activity concentration of $^{40}$K radionuclide was very high compare to other radionuclides in the study. However, the $^{40}$K is a biogenic radionuclide and the human body system controls any excess that is ingested into the body.

The $^{238}$U and $^{232}$Th radioactivity levels in soil were lower than the world average values, however no matter how small radiation exposure or dose may be, it has radiological effect on human [23]. Data are sparse for soil-to-tree (like palm tree) transfer factors of radionuclides but the results are comparable to the reported values for soil to grass in Shyamal et al., [9] and Alausa et al., [22].

## REFERENCES


[1] Mlwilo, N. A., Mohammed, N. K., Spyrou, N.M. (2007). Radioactivity levels of staple foodstuffs and dose estimates for most of the Tanzanian population. Journal of Radiological Protection 27: 471 – 480.

[2] Shiva Prasad, N.G., Nagaiah, N., Ashok, G.V., Karunakara, N., (2008). Concentrations of $^{226}$Ra, $^{232}$Th and $^{40}$K in the soils of Bangalore Region, India, Health Physics 94: 264 – 271

[3] 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

[4] Yassine, T., M. Al-Odat and I. Othman (2003): Transfer of $^{137}$Cs and $^{90}$Sr from typical Syrian soils to crops. *Journal of Food Engineering* XVI: 73–79.

[5] Gaso, M. I., Segovia, N., Morton, O., Cervantes, M. L., Godinez, L., Pena, P., Acosta, E. (2000): $^{137}$Cs and relationships with major and trace elements in edible mushroom from Mexico. TheScience of Total Environment 262: 73-89

[6] Marko, S., and Smodis, B.,(2011): Soil-to-plant transfer factors for natural radionuclides in grass in the vicinity of a former uranium mine. Proceedings of the International Conference Nuclear Energy for new Europe, Bovec, Slovenia, Sept. 12-15, 2011

[7] Gaffar, S. ,Ferdous, M. J. Begum, A. and Ullah, S. M (2014): Transfer of Natural Radionuclides from Soil to Plants in North Western Parts of Dhaka. Malaysian Journal of Soil Science 18: 61- 74

[8] International Atomic Energy Agency (IAEA) (1994): Handbook of parameter values for predicting of radionuclide transfer intemperate environments Technical report series no. 364 Vienna: IAEA.

[9] Shyamal Ranjan Chakraborty, Rezaul Azim, A. K. M. Rezaur Rahman and Rashmi Sarker (2013): Radioactivity Concentrations in Soil and Transfer Factors of Radionuclides from Soil to Grass and Plants in the Chittagong City of Bangladesh Journal of Physical Science, 24(1): 95–113 Penerbit Universiti Sains Malaysia

[10] Natural Habitat (2009): Organic products grown in asustainable habitat: http://www.natural-habitats.com/en/blog/red_palm_oil_extraction_process/(Retrieved 21/09/2016)

[11] Jibiri, N. N. (2000): Application of in-situ gamma ray spectrometry in baseline studies of outdoor radiation exposure levels in Nigeria.A PhD Thesis, University of Ibadan, Nigeria

[12] Rahaman, M.A. (1988). Recent advances in the study of the basement complex of Nigeria. Precambrian: Geology of Nigeria. Publication of the Geological Survey of Nigeria 3: 11- 34.

[13] Musbau F. A. (2014): Geology and Mineral Resources of Oyo State, South Western Nigeria. Journal of Scientific Research & Reports 3(21): 2718-2731

[14] Farai, I. P. and Ademola, J.A., (2001): Population dose due to Building Materials in Ibadan, Nigeria Radiation Protection Dosimetry 95 : 69 –73
[15] Yousef M. I., Abu El-Ela A and Yousef H. A., (2007): Natural Radioactivity levels in surface soil of Kitchener drains in the Nile Delta of Egypt. Journal of Nuclear and Radiation Physics, 2(1): 61-68
[16] Egunyinka, O. A., Olowookere, C. J., Jibiri, N. N., Babalola, I. A., and Obed, R. I. (2009). An elevation of $^{238}U$, $^{40}K$ and $^{232}Th$ concentrations in the top soils of the University of Ibadan (U. I.) Southwestern Nigeria. The Pacific Journal of Science and Technology 10(2): 742-752
[17] Lan, C.Y. and Weng, P.S. (1989): Boby K and $^{40}K$ in Chinese subjects measured with a whole-body Counter, Health Physics 57: 743-746
[18] Alausa, S. K. (2012): Radioactivity in farm soils and food crops grown in Jos and Abeokuta, Nigeria and its associated cancer risks. A PhD Dissertation, University of Ibadan, Nigeria
[19] Martinez-Aguirre, A., Gacia-Leon, M., Ivanovich, M., (1995): U and Th speciation in river sediments. The Science of the Total Environment 173: 203-209
[20] Jibiri N.N., Farai I.P. and Alausa S.K. (2007): Estimation of annual effective dose due to natural radioactive elements in ingestion of foodstuffs in tin mining area of Jos-Plateau, Nigeria Journal of Environmental Radioactivity 94: 31-40
[21] Bettencourt, M. C., Teixeira, M. M. G. R., Elias, M. D. T., Faisca, M. C., (1988): Soil to plant transfer of radium-226. Journal of Environmental radioactivity 6: 49-60
[22] Alausa, S. K. Olabamiji, A. O. and Kola Odunaike (2015): Estimation of natural radionuclides in cattle from a rearing-field at Alabata, Abeokuta Ogun State, Southwestern, Nigeria. Journal of the Nigerian Association of Mathematical Physics, 29: 353-362