Assessment of Environmental Impact in Soil Samples from Selected Market Dumpsites in Ikorodu Metropolis, Lagos State, South Western Nigeria

O.A. Oyebanjo 1,2, O. Sowole 1, O.O. Oyebanjo 3, F. Ayedun 4, T.A. Adagunodo 2, E.O. Falayi 1,2

1 Department of Physics, Tai Solarin University of Education, Ijagun, Ijebu Ode, Ogun State, Nigeria
2 Department of Physics, Covenant University, Ota, Ogun State, Nigeria
3 Department of Quantity Surveying, School of Environmental studies, Lagos state polytechnic, Ikorodu Nigeria
4 Department of Pure and Applied Science, National Open University of Nigeria

Corresponding email: oyebanjokemi@yahoo.com (+2348107454976, +2348058873504); taadagunodo@yahoo.com

Abstract. The study assessed the environmental impact of selected market waste dumpsites in soil samples in Ikorodu metropolis in order to determine the effect of the level of health hazard on the residents of Ikorodu community. The measurement was carried out using a Gamma ray Spectrometer NaI (TI) detector coupled to a Multichannel analyser for spectral analysis. Results revealed that the activity concentration of $^{40}$K in soil samples ranged from $14.84\pm1.07\ \text{BqKg}^{-1}$ to $82.01\pm5.54\ \text{BqKg}^{-1}$ with the highest found in Adamo Market and the lowest was found in Benson market. The activity concentration of $^{238}$U ranged from $0.029\pm0.05\ \text{BqKg}^{-1}$ to $7.65\pm0.9\ \text{BqKg}^{-1}$ with the highest found in Agunfoye Market and the lowest found in Benson market. The activity concentrations of $^{232}$Th ranged from $1.68\pm0.14\ \text{BqKg}^{-1}$ to $3.93\pm0.28\ \text{BqKg}^{-1}$, the highest concentration was found in Agunfoye Market and the lowest was found in Ayangburen Market. The values were within the safety limit recommended by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) with mean value of $13.5 - 69.8\ \text{BqKg}^{-1}$. The Absorbed Dose Rate, Outdoor, Annual Effective Dose Rate, and the Internal and External Hazard Index was also calculated from the activity concentrations which shows that the absorbed dose rates due to gamma rays at 1m above the ground in the study area were within the range of $1.99\ \text{nGyh}^{-1}$ to $7.06\ \text{nGyh}^{-1}$ with an average of $4.08\ \text{nGyh}^{-1}$ which is lower than the UNSCEAR average value of $59\ \text{nGyh}^{-1}$. The annual effective doses are within the range of $0.00$ to $0.01\ \text{mSvy}^{-1}$ with an average value of $0.01\ \text{mSvy}^{-1}$ which were lower when compared with the UNSCEAR value of $0.5\ \text{mSvy}^{-1}$ and $0.07\ \text{mSvy}^{-1}$ respectively. The External Hazard Index in the soil samples ranges from $0.01$ to $0.04$ with an average value of $0.02$ and the Internal Hazard Index ranges from $0.01$ to $0.06$ with an average value of $0.03$ both of which were below the permissible limit respectively, and less than 1. However, the values of the radiological parameters were below the UNSCEAR recommended international limits of $370\text{Bq/kg}$ and within the tolerance level indicating minimal radiological health burden on the people living in the study areas.

Keywords: Absorbed Dose, Equivalent Dose, Dumpsite, Ikorodu, Radioactivity, Waste.
1. Introduction

The rate, type and the quality of soil formed in a particular place is greatly influenced by the activities of man or inhabitants in that community especially in the market place. Wastes in the market places often constitute nuisance and may deteriorate the market place community, if not properly monitored. Soil pollution is the misuse of land in a way which makes it unfit for man`s future needs, such as construction of buildings or the growth of food or other related materials which he uses in his daily life and which could cause either dangerous toxic contamination of air and water resources [15]. Domestic wastes which are being disposed indiscriminately in homes, stores, roadsides and the industrial wastes which are liable to contain traces of radionuclides and are indiscriminately dumped, coupled with the natural or background radiation have made the nooks and crannies of the world generally and the community in specific to be exposed to radiations [2].

Soil provides a direct source of radioactivity in food chain due to its uptake by agricultural plants. The radioactivity caused by radionuclide can be transferred from soil, water, air, to plants, trees and other biological elements and finally to human body. Most radiation in the world is caused naturally through cosmic and terrestrial sources. Most of human exposure to natural radiation comes from random in rocks and soil. The radiation dose actually was a lot higher thousands of years ago than it is today and life still existed and thrived. The worldwide average background radiation dose is 2.4mSv per year. Further researches [2] stated that disposal of waste without adequate management; particularly the radioactive contaminant can expose the populace to radiation hazards.

The contamination of soils and vegetation by heavy metals [21] at dumpsites has been a major concern for all. It has been established that overtime, high and excessive accumulation of heavy metals in the soil may finally contaminate the food chain. Indiscriminate dumping of lasses, municipals waste, industrial (non-hazardous), commercial and household such as food waste, paper, polythene, textiles, scrap metals, glasses, wood, insecticides containers, bulbs, paints, etc., at the market dumpsite, which produces some radioactivity is very common and on the increase. This waste dumpsite may contain a mixture of general waste and toxic, infectious or radioactive wastes and are susceptible to burning and exposure to scavengers. Radioactivity concentration of radionuclide above the permissible level is very harmful to human health [22]. Human beings are exposed to radiations arising from sources including cosmic rays, natural radionuclides in water, air, soil [23].

Environmental pollution is one of the greatest problems that the world is facing today. The indiscriminate waste dumpsite cause soil pollution which lead to unsustainable and wasteful utilization of resource giving rise to dwindling wildlife, more land degeneration [16] and threat to human. Wastes constitute an environmental and public health nuisance in major cities all over the world. Thus, governments consider waste management as an essential social service whose budgetary provision is made in line with population projections [7]. It has also been established that vegetation and environmental fields in Nigeria contain traces of radionuclide [1]. It is an established fact that radiation is present everywhere on the surface of the earth and has been since the formation of the earth.
Naturally occurring radioactive materials are present in air, food and water as well as the ground from which human settlements is built [4], the dumping of large amount of waste materials in sites from oil facilities, and the discharge of waste chemical products from industry and agricultural practices without adequate measure of soil protection result in soil surface and ground water pollution [5]. However, soil radioactivity depends on the types of rocks from which soil is derived [9], but slight variation of radioactivity content in soil can occur with different locations and depth, depending on the type of soil, soil formation and transport processes [14]. Contaminated soil serves as a direct source of radionuclide contamination of all agricultural products [3]. The input of radionuclide to the environment is derived from soil and atmospheric diffusion [18]. In addition, human activities, which produce different forms of radiations, have made the flora and fauna (most especially man) to be exposed to these radiations. Various radioactivity measurements have shown the existence of traces of radionuclide in the staple food consumed in Nigeria [11][8]. Industrial wastes that are liable to contain traces of radionuclide are dumped indiscriminately in the market dumpsite. Hazards posed by dumpsite are not only in term of odour and presence of disease causing microorganism, but can arise from the radiation emanating from the dumpsite [17]. Radiation emission characterization of waste dumpsites and measurement of radiation level in refuse dumps [16] shows the level and long term effects of these radiations if not properly monitored.

2. Study Location

Lagos State is an administrative division created on May 27, 1967 and it is located in the South western part of the country with Ikeja as its capital. Lagos State lies within latitude 6°and 35°N and longitude 3° and 45°E with population of about 17,553,924 (Lagos State Social Security Exercise 2006 Census). Lagos State covers an area of approximately 3,475.1km². Lagos State is divided into five administrative divisions which are further divided into eighteen Local Government Areas. These local governments are; Agege, Alimosho, Ifako-Ijaye, Ikeja, Kosofe, Mushin, Oshodi-Isolo, Shomolu, Apapa, Eti-Osa, Lagos Island, Lagos Mainland, Surulere, Ajeromi-Ifelodun, Amuwo-Odofin, Ojo, Badagry,and Ikorodu. The sampling locations in this Study comprises of; five (5) waste dumpsites which were randomly selected across Ikorodu Metropolis Local Government Area of Lagos State with two samples from each site as shown in Fig. 1.
3. Material and Methods

3.1 Sample Collection and Preparation

Five dumpsites were identified from the city metropolis and at each site; two samples were taken to make a total of 10 samples. The top layer of the soil containing wastes that is yet to decompose were removed. About five hundred grams of each sample were collected in a plastic using digger and spade at the sampling points. During the extraction of soil section, ultimate care was taken to avoid mixing of soil samples. The soil samples were dried at room temperature and then crushed and sieved with a fine mesh having holes in order to remove organic materials, piece of stones, gravels and lumps. Afterwards, the homogenized samples of two hundred and fifty grams were packed to fill a cylindrical plastic container of diameter 7.2cm and 3.2cm height to satisfy the selected optimal sample container used for detector calibration. The samples were properly sealed to avoid escape of $^{222}\text{Rn}$ and stored for 30days to allow $^{238}\text{U}$ and its short-lived progenies to reach secular radioactive equilibrium [20] before gamma counting.

**Figure 1:** Location map showing the access road and locations of sampled points in soil samples from selected market dumpsites in Ikorodu Metropolis
### Table 1: Soil samples location and number of samples.

| Sample Codes | LOCATION       | Number of Samples |
|--------------|----------------|-------------------|
| N1           | Adamo Market   | 2                 |
| N2           | Agunfoye Market| 2                 |
| N3           | Sabo Market    | 2                 |
| N4           | Ayangburen Market| 2             |
| N5           | Benson Market  | 2                 |

3.2 Gamma Counting and Activity Determination.

The soil samples were analyzed using a Gamma Spectrometer model 802(3``x 3`` NaI (TI) Scintillation detector) with serial no 13000850 at the National Institute of Radiation Protection and Research, University of Ibadan campus, Ibadan, Nigeria. The detector is enclosed in a 6cm thick lead shield. IAEA-385 reference soil standard was used for energy and efficiency calibration. The counting time for each of the samples was 36000seconds. Spectrum analysis was based on the output of a Pc based Genie 2k spectrometry software, version 2.1, from Canberra.

3.3 Activity Concentration

The activity concentrations of the natural radionuclides in the measured samples were computed using the relation [19] and [20].

\[
A_c = \frac{N_c L_t}{\sigma} \sigma^{-1}
\]  

(1)

where \(L_t\) is the lifetime of the counting \(\sigma\) is a conversion factor which is constant for each radionuclides at constant geometry and is a characteristic of efficiency of the NaI(TI) detector assembly used at NIRPR, University of Ibadan. All the raw data obtained from the detector were converted to conventional units using calibration factors to determine the activity concentration of \(^{40}\text{K}^{}, \; ^{238}\text{U}^{}, \; \text{and} \; ^{232}\text{Th}^{}\) respectively.

3.4 Absorbed dose rate (DR)

The absorbed dose rates (DR) due to gamma radionuclides in samples were estimated with an assumption that \(^{238}\text{U}^{}, \; ^{232}\text{Th}^{}, \; \text{and} \; ^{40}\text{K}^{}\) are uniformly distributed, and that other radionuclides outside these three contribute insignificantly to the total dose [12][13]. DR is calculated as,

\[
D(\text{nGy} h^{-1}) = 0.462C_u + 0.604C_{Th} + 0.0417C_K
\]

(2)

where DR is the absorbed dose and \(C_u\), \(C_{Th}\), and \(C_K\) are the specific activities measured in Bq/kg for \(^{238}\text{U}^{}, \; ^{232}\text{Th}^{}, \; \text{and} \; ^{40}\text{K}^{}, \) respectively.

3.5 Radium Equivalent Activity (Ra_{eq})

Due to non-uniform distribution of \(^{238}\text{U}^{}, \; ^{232}\text{Th}^{}, \; \text{and} \; ^{40}\text{K}^{}\) in soils, a single parameter is defined with respect to radiation exposure which compares the activity of materials containing
different elements of these primordial radionuclides. This single entity, called the Radium equivalent activity (Ra$_{eq}$) is measured in Bq/kg. It is quantitatively expressed as follows [19, 24-25].

$$\text{Ra}_{eq} (Bq kg^{-1}) = C_U + 1.43 C_{Th} + 0.077 C_K$$

(3)

where, Ra$_{eq}$ is the radium equivalent activity measured in Becquerel per kilogram, and C$_U$, C$_{Th}$, and C$_K$ are the respective specific activities of $^{238}$U, $^{232}$Th, and $^{40}$K, respectively.

3.6 Annual Effective Dose Rate

To estimate the annual effective dose rate (mSv$^{-1}$) due to the natural radionuclides in the soil samples, the following factors were considered: the conversion factor of 0.7 SvGy$^{-1}$[19] which converts the absorbed dose in air to effective dose; the indoor and outdoor occupancy factors of 0.8 and 0.2 were used respectively [13][19], these occupancy factors are the proportion of the total time during which an individual is exposed to a radiation field; eight thousand seven hundred and sixty hours per year; and the factor converting nano to milli (10$^{-6}$).

The effective dose rate was calculated using the equation given by [12][13].

$$\text{IAEDR (mSv}^{-1}) = D(nGyh^{-1}) \times 8760(hy^{-1}) \times 0.8 \times 10^{-6}$$

(4)

$$\text{OAEDR (mSv}^{-1}) = D(nGyh^{-1}) \times 8760(hy^{-1}) \times 0.2 \times 10^{-6}$$

(5)

where (IAEDR) is the indoor annual effective dose rate and (OAEDR) is the outdoor annual effective dose rate.

3.7 Internal Hazard Indices ($H_{in}$)

Internal radiation hazard incurred due to ingested radionuclides from the studied meat samples is quantified in terms of the internal hazard index ($H_{in}$) [19]:

$$H_{in} = \frac{C_U}{185} + \frac{C_{Th}}{259} + \frac{C_K}{4810}$$

(6)

3.8 External Radiation Hazard ($H_{ex}$)

A widely used hazard index (reflecting external exposure) called the external hazard index Hex is defined as follows [19, 24-27]:

$$H_{ex} = \frac{C_U}{370} + \frac{C_{Th}}{259} + \frac{C_K}{4810}$$

(7)

The values of the indices ($H_{in}$, $H_{ex}$) must be less than unity for radiation hazard to be negligible [6].
4. Results

The three primordial radionuclide $^{40}$K, $^{238}$U and $^{232}$Th have been detected and measured in all soil samples from each of the five dumpsites.

Table 2: Activity concentration of in soil samples from selected market dumpsites in Ikorodu Metropolis in Bg/Kg.

| S/N | Sample Codes | Location  | $^{40}$K (Bq/Kg) | $^{238}$U (Bq/kg) | $^{232}$Th (Bq/kg) |
|-----|--------------|-----------|------------------|-------------------|-------------------|
| 1   | AG_A         | Agunfoye  | 27.66±1.94       | 7.65±0.92         | 3.92±0.28         |
| 2   | AG_B         | Agunfoye  | 20.05±1.43       | 6.25±0.93         | 1.91±0.15         |
| 3   | AD_A         | Adamo     | 31.97±1.43       | 1.83±0.36         | 2.62±0.21         |
| 4   | AD_B         | Adamo     | 82.01±5.54       | 1.27±0.22         | 2.37±0.81         |
| 5   | SB_A         | Sabo      | 27.28±1.84       | 4.05±0.76         | 2.61±0.21         |
| 6   | SB_B         | Sabo      | 23.82±1.75       | 3.56±0.62         | 2.52±0.91         |
| 7   | AY_A         | Ayangburen| 32.18±2.21       | 1.81±0.81         | 2.61±0.71         |
| 8   | AY_B         | Ayangburen| 18.60±1.35       | 1.82±0.35         | 1.68±0.14         |
| 9   | BN_A         | Benson    | 18.94±1.15       | 0.29±0.05         | 2.68±0.21         |
| 10  | BN_B         | Benson    | 14.84±1.07       | BDL               | 2.06±0.18         |
|     | Average Value|           | 29.74±1.97       | 2.85±0.50         | 2.50±0.38         |

Note: BDL = Below Detection Limit
Table 3: Calculated Values of Absorbed Dose Rate, Indoor and Outdoor Annual Effective Dose Rate, External and Internal Hazard Index respectively in Soil Samples from Selected Market Dumpsites in Ikorodu Metropolis

| Sample Codes | Absorbed Dose Rate(nGyhr⁻¹) | Annual Effective Dose Rate (mSv yr⁻¹) | Hazard Index |
|--------------|-----------------------------|--------------------------------------|--------------|
|              |                             | Outdoor                              | Indoor       | External | Internal |
| AGₐ          | 7.06                        | 0.01                                 | 0.03         | 0.04     | 0.06     |
| AGₜ          | 4.76                        | 0.01                                 | 0.02         | 0.03     | 0.05     |
| ADₐ          | 3.88                        | 0.00                                 | 0.02         | 0.02     | 0.03     |
| ADₜ          | 5.56                        | 0.01                                 | 0.03         | 0.02     | 0.03     |
| SBₐ          | 4.62                        | 0.01                                 | 0.02         | 0.03     | 0.04     |
| SBₜ          | 4.20                        | 0.01                                 | 0.02         | 0.03     | 0.03     |
| AYₐ          | 3.29                        | 0.00                                 | 0.02         | 0.03     | 0.02     |
| AYₜ          | 2.68                        | 0.00                                 | 0.01         | 0.02     | 0.02     |
| BNₐ          | 2.70                        | 0.00                                 | 0.01         | 0.02     | 0.02     |
| BNₜ          | 1.99                        | 0.00                                 | 0.01         | 0.01     | 0.01     |
| Maximum      | 7.06                        | 0.01                                 | 0.03         | 0.04     | 0.06     |
| Average      | 4.08                        | 0.01                                 | 0.02         | 0.02     | 0.03     |
| World Average| 59                          | 0.07                                 | 0.50         | 1        | 1        |

5. Discussion

Table 2 shows the activity concentrations of $^{40}$K, $^{238}$U and $^{232}$Th. Results from Agunfoye market (AGₐ), shows that the amount of $^{40}$K present in the dumpsites were 27.66±1.94 Bq/Kg and that of $^{238}$U was 7.65±0.92 Bq/Kg while the level of $^{232}$Th was 3.93±0.28 Bq/Kg. In Agunfoye market (AGₜ), the activity concentrations were 20.05±1.43 Bq/Kg,6.25±0.93 Bq/Kg, and 1.91±0.15 Bq/Kg for $^{40}$K, $^{238}$U and $^{232}$Th respectively.

Adamo dumpsites (ADₐ) shows the activity concentration for $^{40}$K to be 31.97± 1.43 Bq/Kg, 1.87±0.36 Bq/Kg for $^{238}$U and 2.62±0.21 Bq/Kg for $^{232}$Th. In Adamo dumpsite (ADₜ), the activity concentrations are 82.01±5.54 Bq/Kg, 1.27±0.22 Bq/Kg, 2.37±0.18 Bq/Kg for $^{40}$K, $^{238}$U and $^{232}$Th respectively. For Sabo (SBₐ) and Sabo (SBₜ), the level of radionuclide presents for the two dumpsites ranged from 27.28±1.84 Bq/Kg to 23.82±1.75 Bq/Kg for $^{40}$K, $^{238}$U ranged from 4.05±0.76 Bq/Kg to 4.05±0.76 Bq/Kg while $^{232}$Th ranged from 2.61±0.21Bq/Kg to 2.25±0.19 Bq/Kg.

Results for Ayangburen (AYₐ) and Ayangburen (AYₜ) showed the level of radionuclide presents for the two dumpsites ranging from 32.18±2.21 Bq/Kg to 18.62±1.35 Bq/Kg for $^{40}$K, 1.18±0.18 Bq/Kg, 1.82±0.35 Bq/Kg for $^{238}$U and 2.16±0.17 Bq/Kg, 1.68±0.14 Bq/Kg for $^{232}$Th.

Benson (BNₐ) Benson (BNₜ) ranged from 18.94±1.15 Bq/Kg to 14.84±1.07 Bq/Kg for $^{40}$K,0.29±0.05 Bq/Kg and BDL for $^{238}$U and 2.68±0.21 Bq/Kg, to 2.06±0.18 Bq/Kg for $^{232}$Th.
Generally, the activity concentration of $^{40}$K in the soil samples is significantly higher than that of $^{238}$U and $^{232}$Th as shown in Fig. 2 and Table 2, ranging from 14.84±1.07 Bq/Kg to 82.01±5.54 Bq/Kg with the highest value found in Adamo (AD$_B$) market and the lowest was found in Benson (BN$_B$) market. Having an average value of 29.74±1.97 Bq/Kg. Table 2 and Fig. 2 show that $^{238}$U ranging from 0.29±0.05 Bq/Kg to 7.65±0.92 Bq/Kg with an average activity concentration of 2.85±6.50 Bq/Kg, and $^{232}$Th ranging from 1.68±0.14 Bq/Kg to 3.93±0.28 Bq/Kg with an average activity concentration of 2.50±0.38 Bq/Kg. The above results revealed that all the locations were within the safety limit of world mean value of 13.5 to 69.8 Bq/Kg recommended by UNSCEAR. In order to assess the health effects of the people living in the study area, the Absorbed Dose Rate, Indoor and Outdoor Annual Effective Dose Rate, and the Internal and External Hazard Index has also been calculated from the activity concentration of $^{40}$K, $^{238}$U, and $^{232}$Th respectively, and the values are presented in Table 3, which shows that the absorbed dose rates due to gamma rays at 1m above the ground in the study area are within the range of 1.99 nGyh$^{-1}$ to 7.06 nGyh$^{-1}$ with an average of 4.08 nGyh$^{-1}$ which is lower than the world average value of 59 nGyh$^{-1}$[19]. The indoor annual effective doses are within the range of 0.01 to 0.03 mSvy$^{-1}$ with an average value of 0.02 mSvy$^{-1}$ while the outdoor annual effective doses are within the range of 0.00 to 0.01 mSvy$^{-1}$ with an average value of 0.01 mSvy$^{-1}$ both of which are lower when compared with the world average value of 0.5 mSvy$^{-1}$ and 0.07 mSvy$^{-1}$ respectively [19]. The External Hazard Index in the soil samples ranges from 0.01 to 0.04 with an average value of 0.02 and the Internal Hazard Index ranges from 0.01 to 0.06 with an average value of 0.03 both of which are below the permissible limit (i.e. ≤1).

6. Conclusion and Recommendation

In conclusion, Potassium $^{40}$K, Uranium $^{238}$U and Thorium $^{232}$Th are the three naturally occurring radionuclides detected in the soil samples from the dumpsites. The radiation dose rate, Absorbed dose rate, Average Effective dose rate, and the Internal and External Hazard index, of the waste dumpsites in some places in Ikorodu metropolis has also been investigated in this study. Despite the fact that all levels of ionizing radiation are hazardous to human
health [10] the exposure level of the emitted radiation on the populace of the study area is low when compared with Nigeria and World average which is 70µSvyr⁻¹.

The fear of serious health hazards from the exposure to radiation emanating from the dumpsites in Ikorodu should not be entertained. However, the waste from refuse dumpsite could be converted to compost manure particularly the organic waste for the use of farmers. It could be recycled to improve aesthetically the environment of the waste site. Also waste dumpsite should be located far away from residential areas; builders should be discouraged from building houses near dumpsites. Waste to wealth approach should be incorporated by the government as well as carrying out regular investigations to monitor the level of radiation emission from dumpsites in the city to avoid high level of radiation emission outbreak in subsequent years.

Acknowledgment
We thank the publication support received from Covenant University, Nigeria.

REFERENCES

[1]. Akinloye, M. K & Olomo, J. B. (2005). The radioactivity in some grasses in the environment of nuclear research facilities located within the OAU, Ile-Ife, Nigeria. J. Phys., 17s; 219-225.

[2]. Avwri, G. O., Nte, F. U. & Olarenwaju, A. I. (2011). Determination of Radionuclide Concentration of Landfill at Eliozu, Port Harcourt, Rivers State.” Sciatica Africana, vol.10 (No.1), 46-57.

[3]. Banwo, A. A., Jimba, B. W., & Elegba, S. B (1990) “Comparison of natural background radiation in soils from Zaria & Jos, Nigeria ”. Proceeding of the 13th Annual conference, Nigeria Institute of Physics 2-4.

[4]. Ciezkowski, W & Pryzylibski, T. A. (1997). Radon in waters from Health Resorts of the Sudety Mountains (SW Poland). Applied Radiation and isotopes. 48 (6): 855-856.

[5]. Cothern, C. R. & Lappenbusch, W. L. (1983). Occurrence of uranium in drinking water in the U. S. Health physics 45, 88-99.

[6]. Diab, H.N.T. (2008). Evaluation of natural radioactivity in cultivated area around a fertilizer factory. Nuclea. Rad. Physc, 53-62.

[7]. Eja, M. E., Alobi, N. O., Ikpeme, E. M, Ogri, O. R & Iyang, A. O. (2010). Environmental and Public health-related assessment of solid waste management in Uyo, AkwaIbom state, Nigeria. World Journal of Applied Science and Technology 2(1):110-123.

[8]. Eyebiokin, M. R., Arogunjo, A. M., Oboh, G., Balogun F. A. & Rabiu, A. B. (2005). Activity concentration & absorbed dose equivalent of commonly consumed vegetables in Ondo State, Nigeria. Nig. J. Phys., 17s; 187-191.

[9]. Holkkio, J. & Liukkonen, S. (1992) “Radon diffusion in finish glacial till soil”. Radiation Protection Dosimetry 45, 231-233.
[10]. Imtiaz, M. A., Aleya, B., Moua, A. S. & Zaman, M. A. (2005). Measurement of radioactivity in books and calculations of resultant eye doses to readers. Health phys., 88:169-174.

[11]. Jibiri, N. N., Farai, I. P. & Alausa, S. K. (2007). Activity concentration of Ra-226, Th-228 and K-40 in different food crops from a high background radiation area in Bisichi Jos Plateau State, Nigeria. Radiat. Environ. Biophys., 46: 53-59.

[12]. Kessaratikoon, P. & Awaekachi, S. (2008) Natural radioactivity measurement in soil samples collected from municipal area of Hat Yai District in Songkhla Province, King Mongkut’s Institute of technology Ladkrabang Science Journal, 8(2) 52-58.

[13]. Masok, F. B., Dawam, R. R. & Mangset, W. E (2015).Assessment of Indoor and Outdoor Background Radiation Levels in Plateau State University Bokkos Jos, Nigeria Journal of Environment and Earth Science 5(8):1-4.

[14]. McAulay, I.R & Marsh, D. (1992). “Radium -226 concentrations in soil in the Republic of Ireland”. Radiation Protection Dosimetry 45,265-267.

[15]. Nwajei, G. E. & Iwegbue, C. M. A. (2005). Trace metals contamination in soils under cattle Pens in Warri Delta State of Nigeria. A Conference Paper Delivered at the 28th Annual International Conference, September 26-30, 2005, Chemical Society of Nigeria, Maiduguri, Nigeria, pp: 680-683.

[16]. Odunaike, R. K., Alausa, S.K., Oyebanjo, O. A., Ijeoma G. C. & Alo, A. O. (2008). Measurement of radiation level in refuse dumps across Lagos metropolis, Southwestern Part of Nigeria. Environ. Res. J., 2: 174-176.

[17]. Ojoawo, S., Agbede, O.& Sangodoyin, A. (2011).On the Physical Composition of Solid Wastes in Selected Dumpsites of Ogbomosoland, South-Western Nigeria. Journal of Water Resource and Protection, 3, 661-666 doi:10.4236/jwarp.2011.39076.

[18]. Papp, Z. & Daroczy, (2002). Significant radioactive contamination of soil around a coal-fired thermal plant”. Journal of Environmental Radioactivity 59,191-205.

[19]. United Nation Scientific committee on the effects of Atomic Effects of Atomic Radiation (UNSCEAR) (2000). Radiation sources and effects of ionizing radiation. New York, USA: United Nations. Report of the United Nation Scientific Committee on the effect of Atomic Radiation to General Assembly.

[20]. Veiga, R., Sanche, N., Anjos, R. M., Macario, K., Bastos, J. & Iquateny, M. (2006). Measurement of natural radioactivity in Brazillian Beach sands. Radiation Measurements, 41(2), 189-196.

[21]. Adagunodo T.A., Sunmonu L.A., Emetere M.E. (2018). Heavy Metals’ Data in Soils for Agricultural Activities. Data in Brief, 18C: 1847 – 1855. https://doi.org/10.1016/j.dib.2018.04.115.

[22]. Adagunodo T.A., Sunmonu L.A., Adabanija M.A., Suleiman E.A., Odetunmibi O.A. (2017). GeoeXploration of Radioelement’s Datasets in a Flood Plain of Crystalline Bedrock. Data in Brief, 15C: 809 – 820. http://dx.doi.org/10.1016/j.dib.2017.10.046.
[23]. Adagunodo T.A., Hammed O.S., Usikalu M.R., Ayara W.A., Ravisankar R. (2018). Data on the Radiometric Survey over a Kaolinitic Terrain in Dahomey Basin, Nigeria. Data in Brief, 18C: 814 – 822. https://doi.org/10.1016/j.dib.2018.03.088.

[24]. Adagunodo T.A., George A.I., Ojoawo I.A., Ojesanmi K. and Ravisankar R. (2018). Radioactivity and Radiological Hazards from a Kaolin Mining Field in Ifonyintedo, Nigeria. MethodsX, 5C: 362 – 374. https://doi.org/10.1016/j.mex.2018.04.009.

[25]. Omeje M., Adagunodo T.A., Akinwumi S.A., Adewoyin O.O., Joel E.S., Husin W. and Mohd S.H. (2019). Investigation of Driller’s Exposure to Natural Radioactivity and its Radiological Risks in Low Latitude Region using Neutron Activation Analysis. International Journal of Mechanical Engineering and Technology, 10(1): 1897 – 1920.

[26]. Adagunodo T.A., Sunmonu L.A., Adabanija M.A., Omeje M., Odetunmibi O.A., Ijeh V. (2019). Statistical Assessment of Radiation Exposure Risks of Farmers in Odo Oba, Southwestern Nigeria. Bulletin of the Mineral Research and Exploration, http://dx.doi.org/10.19111/bulletinofmre.495321.

[27]. 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, 9(9): 1047-1059.