ESTIMATION OF NATURAL RADIONUCLIDES IN GRASSES, SOILS, AND CATTLE-DUNGS FROM A CATTLE REARING-FIELD AT MANGORO-AGEGE, LAGOS STATE, NIGERIA

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Abstract: Estimating the levels of radiation in the environment is crucial in implementing appropriate controls towards radiological protection. The aim of this study was to determine the radioactivity levels in the grass, soils and dung using a well calibrated thallium-doped sodium iodide scintillator detector. The radioactivity level in the soil ranged from 301.18 to 440.48 Bqkg^{-1} with a mean value of 403.07±33.85 Bqkg^{-1}; 10.19 to 13.05 Bqkg^{-1} with a mean value of 11.47±0.75 Bqkg^{-1} and 9.12 to 11.97 Bqkg^{-1} with a mean value of 10.44±0.75 Bqkg^{-1} for ^{40}K, ^{238}U and ^{232}Th. The activity concentrations in the grass samples ranges from 202.41 to 99.57 Bqkg^{-1} with a mean value of 115.46±21.68 Bqkg^{-1}; 11.21 to 8.44 Bqkg^{-1} with a mean value of 10.06±0.75 Bqkg^{-1} and 10.50 to 3.00 Bqkg^{-1} with a mean value of 8.31±2.76 Bqkg^{-1} for ^{40}K, ^{238}U and ^{232}Th while the activity concentration in the dung samples ranged from 115.21 to 225.44 Bqkg^{-1} with a mean value of 184.90±40.92 Bqkg^{-1}; 10.13 to 13.17 Bqkg^{-1} with a mean value of 11.50±0.78 Bqkg^{-1} and 8.12 to 11.28 Bqkg^{-1} with a mean value of 10.20±0.71 Bqkg^{-1} for ^{40}K, ^{238}U and ^{232}Th. The mean values of soil-grass transfer factors were 0.29±0.05, 0.88±0.10 and 0.80±0.27 for ^{40}K, ^{238}U and ^{232}Th respectively. The values reported for the soil samples were lower than the world average values of 410.0 Bqkg^{-1}; 35.0 Bqkg^{-1} and 28.0 Bqkg^{-1} for ^{40}K, ^{238}U and ^{232}Th. The results indicated a possible low radiological effect on human feeding on cattle beef in the study area.

Keywords: Cattle-dung, grass, Lagos, natural radionuclides, Nigeria, rearing-field, soil

Introduction

Estimating the levels of radiation in the environment is crucial in implementing appropriate controls for the sake of radiological protection since the constituents that make up the environment contains various amount of radionuclides and their decay products. The major ways by which humans become exposed to these radiations are radiation from sources outside the body (external exposure), radionuclides that are ingested through consumption of food and water or as inhaled radioactive gases (internal exposure) (UNSCEAR, 2008). The two main sources of exposure are cosmic rays that are released from outer space and from the surface of the sun and terrestrial radionuclides that occur in the earth crust in building materials and in the dust, water and food and the human body at large (UNSCEAR, 2000). Also, traces of radionuclides are found in water, air, soil, and human bodies. We inhale and ingest radionuclides every day of our lives and radioactive material has been ubiquitous on earth since its creation (UNSCEAR, 2008). The presence of natural radioactivity in soil results in internal and external exposure to humans (L'Annunziata, 2007). The most commonly encountered radionuclides that irradiate the human body through external exposure (primarily by gamma radiation) are ^{238}U and ^{232}Th, their radioactive decay products and ^{40}K. The naturally occurring radioactive materials are known as the largest sources of exposure to human (UNSCEAR, 2000).

Naturally occurring radionuclides of terrestrial origin also referred to as primordial radionuclides, they are present in various degrees in the various components of the environment. These radionuclides with half-lives long enough comparable to the number of years the earth has been in existence as well as their progenies exist in substantial amount in rocks and soil. They, therefore, contribute significantly to population exposure. Radionuclides such as ^{40}K, ^{238}U and ^{232}Th which are present in trace amounts in soil represent the major source of external exposure due to gamma radiation (Hafezi *et al.*, 2005). Radionuclides in solution can then be incorporated through root hair and then to the root of grasses for onward transfer to the leave system of the grasses that cattle feed upon. In most cases, this is facilitated by their chemical similarity with other element that the grasses usually depend on for growth. The ingestion of radionuclide through the grass by cattle is dependent on the concentration of radionuclides in the grasses consumed (Salbu *et al.*, 2004). It is therefore very important to assess the radiological safety of grasses consumed by cattle. This is because the ingestion of meats loaded with radionuclides has the potential of exposing human beings to a high level of radiation dose. Furthermore, radionuclides with relatively long half-lives are considered human health risk as they can get into the human system through the food chain and thereby increase the radiation burden for many years (Abu-Khadral *et al.*, 2008).

Cattle products are important contributors to total food production. The addition of milk and meat provides protein, calcium, vitamins, and other nutrients that could be lacking in diets that are exclusively made up of staples such as cereals. The poor, in particular, use organic fertilizer from cattle operations, especially when rising petroleum prices make chemical fertilizers unaffordable (Mofunanya *et al.*, 2015). Cattle also store value and provide insurance for people who have no other financial markets available to them. Cattle trade provides the largest livestock market in Nigeria. Millions of Nigerians made their livelihood from the beef enterprises as producer, marketers, and transporters; others, as processors of beef products, feed millers, veterinary services and in agricultural pieces of machinery. It also generates a lot of revenue to the government through various forms of taxations. Nigeria plays a vital role in the livestock economy of Africa.

An important goal of the United Nations (UN) relating to sustainable food security is to assist members' states in ensuring that people have access to food that is sufficient, nutritionally adequate and above all considered safe for human consumption (Jibiri *et al.*, 2006). The presence of radionuclide in soil above a certain threshold leads to contamination of grass since grasses derived their nutrients for growth from the topsoil on which they are grown. The natural radioactivity levels in soils of some locations in Abeokuta were reported to be significantly higher than the world average (Alausa *et al.*, 2015). Hence, the radioactivity levels in grasses and vegetation grown in such soils may be enhanced through the plant-root uptake of radionuclides and such, animals grazing on the grasses may have a high retention of natural radionuclides in their body. The activity concentration of radionuclides in the soil of Agege was

reported to be significantly high (Ilori *et al.*, 2017). Therefore, this study is significant in accessing the activity concentration of natural radionuclides in soil, grass and dung of cattle in a cattle-rearing field at Agege, Lagos state and evaluates the amount of radionuclides retained in the cattle in order to access the likely health cancer risk due to ingestion of beef from the cattle in the area.

Materials and Methods

Geographical description of the study area

Mangoro-Agege, the study area, is a boundary city between Lagos and Ogun state sharing same geological setting as Abeokuta, which unconformably overlies the rocks of the Basement Complex to the Quaternary Deltaic sands (Obiora & Onwuka, 2005). Agege is directly underlain by the Benin Formation. The Benin Formation consists largely of sands/sandstones with lenses of shales and clays. The geologic succession in Lagos spans through the Cretaceous Abeokuta Formation. Agege is a suburb and Local Government Area in Ikeja Division of Lagos State, Southwestern, Nigeria. It has geographical coordinates of $6^0 37' 17''$ North and $3^0 19' 33''$ East with a mean annual temperature of 27^0C, it has a density (inh.per km2) of 41,071, land mass area (in km2) of 17 km2, annual rainfall of 1540 mm and the population in the area is 459,939 (NPC, 2016). From the western part of Lagos state Nigeria, the cattle rearing field is at the boundary of Agege to Abeokuta expressway leading to Ikeja local government area (Figs 1a&b).

Fig. 1a: Map of Nigeria showing Lagos State (Source: Federal Government of Nigeria, 2008)

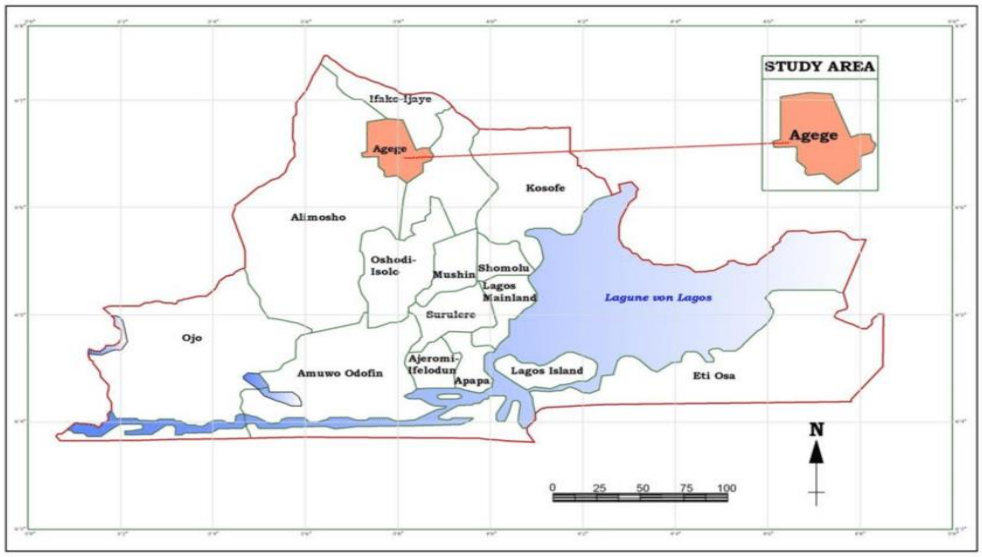

Fig. 1b: Map of Lagos State showing Agege, the study area (Modified after Source: Federal Government of Nigeria, 2008)

Samples collection

A total of 20 soil samples, 20 grass samples, and 20 cattle dung samples were collected for the present study, these points of the collection were marked out using a Global Positioning System (GPS) (Table 1). Grass samples were uprooted from the grazing ground and the whole grass was collected, Soil samples were collected from depths 5 cm at the same location where grass samples were collected. The dung samples were collected at various locations within the grazing field where the cattle directly defecated. At the collection point, all samples were wrapped in separate black plastic bags and were well labeled with a paper masking tape. The samples were then transported to the laboratory for preparation. Below is the GPS representation of the location of samples.

Table 1: Some samples location mapped out by GPS

Samples	GPS (Location)	Samples	GPS (Location)
1	N 06^0 36.801 E 003^0 19.681	11	N 06^0 37.325 E 003^0 18.820
2	N 06^0 36.815 E 003^0 19.662	12	N 06^0 36.425 E 003^0 19.620
3	N 06^0 36.808 E 003^0 19.673	13	N 06^0 37.035 E 003^0 19.305
4	N 06^0 36.825 E 003^0 19.650	14	N 06^0 37.423 E 003^0 19.321
5	N 06^0 36.925 E 003^0 19.647	15	N 06^0 36.812 E 003^0 19.723
6	N 06^0 36.961 E 003^0 19.663	16	N 06^0 36.308 E 003^0 19.628
7	N 06^0 37.000 E 003^0 19.590	17	N 06^0 37.435 E 003^0 18.039
8	N 06^0 37.125 E 003^0 19.542	18	N 06^0 37.306 E 003^0 18.596
9	N 06^0 37.145 E 003^0 19.550	19	N 06^0 37.125 E 003^0 18.345
10	N 06^0 37.240 E 003^0 19.613	20	N 06^0 36.806 E 003^0 19.675

Samples preparation

Soils were well mixed after removing extraneous materials such as roots, pieces of stones and gravels. Samples were then weighted and dried into an electric oven at 110^0C for 4 days

until a constant dry weight was obtained. After crushing and mixing thoroughly, soil samples were shaken in a sieve shaker and were scaled in 200 g each (Abbady *et al.*, 2005).

Grass samples were cleared by fresh water for removing the dust and surface contaminations. All the samples were then dried under the sun and humidity condition for 2 days, they were then weighed in 200 g each (Ababneh, 2009). The samples were charred and then finely ground into fine powder, the ash samples were cooled at room temperature. The cooled ash samples were weighed (IAEA, 1989).

Dung samples were dried for 4 days in an electric oven of 110^0C to obtain a constant dry weight. The samples were then stored for about 30 days, to reach secular equilibrium between ^{226}Ra (daughter of ^{238}U and ^{232}Th with their daughter nuclei, in a 250 cm^3 container with a cap and wrapped with thick vinyl tapes. This was done in order to allow radon and its short-lived progenies to reach secular radioactive equilibrium. Furthermore, all the containers where samples were kept were preserved airtight by plastic packets to ensure that ^{222}Rn and ^{220}Rn are confined within the volume (Alharbi & El-Taher, 2013**)**.

Detection of radiation by NaI(TI) crystal

When incoming radiation is incident on the crystal, it gives up its energy E completely to the scintillator resulting in the production of N number of photons given by:

$$N = \frac{E_q}{\omega_0} \quad (1)$$

Where E_q is the luminescence quantum efficiency, which is the probability of a photoelectric interaction of the incident photon and ω_0 is the average energy of a single photon which is about 3.0eV for NaI(TI). These N photons impinge on the photocathode of the photomultiplier tube and are converted into photoelectrons, which are directed to the incident on the first dynode of the photomultiplier tube. The total number N_c of photoelectrons at the first dynode is given by:

$$N_c = \frac{E_q}{\omega_0} mc_{p.e} g_c G \quad (2)$$

Where G is the light collection efficiency of the photocathode which gives the function of photons that impinge on the photocathode which are converted into photoelectrons; $c_{p.e}$ is the photo-quantum efficiency of the window-cathode system, m is a factor between 0 and 1 depending on the degree of spectral matching between the scintillation spectrum and the spectral responses of the photocathode; g_c is the efficiency with which the first dynode collects the number of electrons arriving. These efficiencies are affected by a number of factors; G is a factor determined by self-absorption, reflection loses, light trapping, optical flaws and the optical geometry of the photocathode. In NaI(TI), G is usually made nearly unity by coating the director with a reflector like MgO thereby making self-absorption very small. The term $mc_{p.e}g_c$ depends in a complex manner, on the wavelength and the point of the incident of the photons on the photocathode. Factor $c_{p.e}$ depends on the cathode material and its thickness while g_c depends on the structure of the dynode and its potential. The total number of electrons Q at the last dynode collected at the anode is given as:

$$Q = MN_i \quad (3)$$

Where M is the overall gain resulting from the k successive multiplications of N_c electrons at each dynode given by:

$$M = \prod_i^t m_i \quad (4)$$

Where m_i is the multiplication at the i^{th} dynode.

It is roughly proportional to the voltage between the dynodes. It can be observed from equations 2 and 3 that Q is a linear function of the energy E of the initial incident photon. Apart from the number of electrons given by equation 8, there are a number of electrons produced due to thermionic emission in the photomultiplier tube. The number of electrons with thermal energy greater than the work function of photocathode which is emitted as thermionic electrons is a function of temperature as given in the equation:

$$n_T = ATe^{\frac{Qe}{KT}} \quad (5)$$

Where T is the absolute temperature, e is the electronic charge, k is the Boltzmann constant, A and Q are characteristics of the cathode material.

Activity determination

A well calibrated NaI(TI) and a well-shielded detector coupled to a computer resident quantum MCA2100R Multichannel analyzer for 36,000s were employed. An empty container under identical geometry was also counted for the same time. 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.

$$C_s = \frac{C_\alpha}{P_\gamma(\frac{M_s}{V_s})\varepsilon_\gamma t_c} (BqKg^{-1}) \quad (6)$$

Where C_s is the sample concentration, C_α is the net peak energy, ε_γ is the efficiency of the detector for a γ-energy of interest, M_s/V_s is the sample mass per volume of soil, t_c is the total counting time and P_γ is the abundance of the γ-line in a radionuclide.

The efficiency calibration of the detector was done using a reference standard mixed source traceable to Analytical Quality Control Service (AQCS, USA), which has certified activities of the selected radionuclide and has a geometrical configuration identical to sample container. The standard sources contained ten known radionuclides. The energy calibration was also performed by using the peaks of the radionuclide present in the standard sources. The channel number is proportional to energy; the channel scale was then converted to an energy scale. This produces an energy calibration curve, i.e. energy versus channel.

Transfer factor

The soil-to-grass transfer factor (TF) measured the transfer of radionuclides from the soil to grass. In soil, each radioactive element follows complex dynamics in which a part of its concentration is transported into the soil solution, while another part gradually becomes strongly bound to the particles of the soil. The portion of these radionuclides, which is in the soil solution, can be incorporated via the root into the grass (Alharbi & El-Taher, 2013**)**.

From observed activity concentrations of the radionuclides in the grass and in the corresponding soil, the transfer factor values were calculated according to the equation:

$$TF = \frac{A_g}{A_s} \quad (7)$$

Where: A_g = Activity of radionuclides in the grass (BqKg^{-1} dry weight); A_s = Activity of radionuclides in soil (BqKg^{-1} dry weight)

The dry weight was preferred because the amount of radioactivity per kilogram dry weight is much less variable than the amount per unit of fresh weight. The soil-to-grass TF can be used as an index for the accumulation of trace elements by plants or the transfer of elements from the soil to the plant.

Result and Discussions

Activity measurement in the soil samples

In the study, the radioactivity level in the soil ranged from 301.18 to 440.48 Bqkg^{-1} with a mean value of 403.07±33.85

Bqkg^{-1} for ^{40}K; 10.19 to 13.05 Bqkg^{-1} with a mean value of 11.47±0.75 Bqkg^{-1} for ^{238}U and 9.12 to 11.97 Bqkg^{-1} with a mean value of 10.44±0.75 Bqkg^{-1} for ^{232}Th (Table 2). The activity concentrations of ^{40}K, ^{238}U and ^{232}Th radionuclides in the soil samples were higher than the corresponding values in grass samples. This affirmed the general assertion that only a fractional part of the radionuclides in the soil is transferable to the plant. The activity concentrations of ^{40}K, ^{238}U and ^{232}Th were lower than the values of 411±341 Bqkg^{-1} for ^{40}K; 184±205 Bqkg^{-1} for ^{226}Ra and 65±29 Bqkg^{-1} for ^{238}U reported for Abeokuta (Jibiri & Ajao, 2005). The values were also lower than the world average values of 410.0 Bq kg^{-1} for ^{40}K; 35.0 Bq kg^{-1} for ^{238}U and 28.0 Bq kg^{-1} for ^{232}Th (UNSCEAR, 2000). The low activity concentrations of radionuclides in the soil samples from the study may be attributed to the underlain Benin formation, which consists of largely sands/sandstones with lenses of shales and clays overlain by the Basement complex (Obiora & Onwuka, 2005). The ranges of activity concentration of the radionuclides are similar to the values of 12 to 31 Bq kg^{-1} for ^{238}U; 14 to 36 Bq kg^{-1} for ^{232}Th and 267 to 867 Bq kg^{-1} for ^{40}K for Tehran-Iran (Hafezi *et al.*, 2005).

Table 2: Activity concentrations in soil samples

Samples	^{40}K (Bqkg^{-1})	^{238}U (Bqkg^{-1})	^{232}Th(Bqkg^{-1})
1	429.11±24.43	13.05±0.84	11.97±0.57
2	421.43±38.00	12.13±0.19	11.03±0.16
3	413.78±26.88	11.01±0.50	10.09±0.60
4	301.18±15.75	11.15±0.99	12.08±2.25
5	412.16±10.01	10.19±1.01	9.12±0.08
6	418.22±13.43	10.93±0.67	10.01±0.21
7	420.02±10.16	11.61±0.40	10.13±1.13
8	422.18±21.57	12.29±2.30	10.25±1.70
9	412.31±41.07	12.03±1.95	10.13±0.30
10	420.73±24.08	11.87±0.80	10.58±1.65
11	404.41±17.05	11.68±2.34	9.93±0.54
12	412.24±25.54	11.11±1.98	9.63±0.69
13	420.07±13.89	10.54±1.67	9.33±0.86
14	361.24±22.34	10.23±0.80	10.20±2.31
15	356.67±12.79	10.67±1.50	10.60±0.17
16	352.10±16.72	11.11±0.45	11.00±1.90
17	420.34±17.12	11.74±0.60	10.36±0.89
18	401.68±21.38	11.96±1.40	10.64±0.43
19	421.08±22.56	12.01±0.99	10.81±1.41
20	440.48±20.05	12.06±0.32	10.96±0.71
Mean ±σ	403.07±33.85	11.47±0.75	10.44±0.75

Activity measurement in the grass samples

The activity concentrations of ^{40}K, ^{238}U and ^{232}Th in the grass samples ranges from 202.41 to 99.57 Bqkg^{-1} with a mean value of 115.46±21.68 Bqkg^{-1} for ^{40}K; 11.21 to 8.44 Bqkg^{-1} with a mean value of 10.06±0.75 Bqkg^{-1} for ^{238}U and 10.50 to 3.00 Bqkg^{-1} with a mean value of 8.31±2.76 Bqkg^{-1} for ^{232}Th. ^{40}K activity concentration exhibited the highest values among other radionuclides as shown in Table 3. Grasses and other plants derive their nutrients from the topsoil on which they are grown and the presence of radionuclides in such soil above certain threshold encourages the soil-to-plant uptake of such radionuclides (Jibiri *et al.*, 2006). The average radioactivity concentrations in elephant grasses as 25.7±5.5 Bqkg^{-1} for ^{238}U and 33.4±3.9 Bqkg^{-1} for ^{232}Th reported for Ibadan (Jibiri & Ajao, 2005). The mean radioactivity levels of 291.8±58.3 Bqkg^{-1} for ^{40}K; 11.7±0.8 Bqkg^{-1} for ^{238}U and 9.3±2.0 Bqkg^{-1} for ^{232}Th reported in grasses [14] were higher than the corresponding values in the present study. In the present study, the values of ^{40}K were lower while the values of ^{232}Th were higher than the values reported for vegetables in Kuca, Jos (Alausa, 2012). The range of ^{40}K activity concentrations in the study was lower when compared to the range of 201 to 684 Bqkg^{-1} but the ^{232}Th activity concentrations in the study were higher than the values in vegetables consumed in Jordan (Jamal, 2015).

Table 3: Activity concentrations in grass samples from the study area

Samples	^{40}K(Bqkg^{-1})	^{238}U (Bqkg^{-1})	^{232}Th(Bqkg^{-1})
1	109.48±25.80	9.83±0.85	9.76±1.10
2	112.12±30.10	10.01±1.01	10.01±1.24
3	114.76±23.45	10.01±0.46	10.30±1.45
4	105.12±11.03	10.97±1.27	3.00±1.12
5	125.03±25.46	9.02±0.20	3.00±1.45
6	121.10±18.94	8.73±0.69	3.00±2.89
7	117.17±19.28	8.44±1.21	3.00±3.50
8	202.41±15.89	10.36±0.92	10.18±4.02
9	99.57±21.41	10.11±1.75	9.31±3.05
10	100.02±16.22	10.24±0.51	9.14±2.25
11	100.47±21.27	10.37±0.87	8.97±3.16
12	102.57±20.57	10.11±2.61	10.11±7.67
13	107.03±13.56	11.11±0.82	9.02±5.53
14	108.62±12.89	11.16±0.69	9.08±11.50
15	110.21±18.25	11.21±3.74	9.10±2.25
16	113.11±23.69	9.85±1.23	9.03±3.81
17	110.56±23.43	9.49±0.98	10.07±1.10
18	120.13±20.45	9.78±1.20	9.54±0.98
19	116.61±27.78	10.04±1.61	10.02±2.56
20	113.09±16.08	10.30±0.58	10.50±1.14
Mean ±σ	115.46±21.68	10.06±0.75	8.31±2.76

Table 4: Activity concentrations in dung samples from the study area

Samples	^{40}K (Bqkg^{-1})	^{238}U (Bqkg^{-1})	^{232}Th(Bqkg^{-1})
1	225.44±30.10	11.73±1.01	9.80±0.24
2	212.32±32.89	11.35±1.17	10.33±0.38
3	199.20±41.03	10.97±0.57	10.36±0.60
4	221.02±40.05	13.17±0.44	8.12±1.41
5	212.10±25.86	10.13±0.20	10.01±0.81
6	210.14±33.82	10.53±0.68	10.30±1.34
7	150.14±21.93	10.93±0.28	10.59±1.11
8	208.14±26.80	11.76±0.52	10.18±1.02
9	127.43±23.96	11.97±0.75	11.00±0.40
10	121.32±19.28	12.20±0.81	11.14±0.83
11	115.21±33.16	12.07±1.61	11.28±0.61
12	211.23±29.17	10.32±1.20	10.17±1.31
13	219.53±36.94	11.29±1.29	9.76±0.74
14	216.67±27.98	11.64±0.92	9.59±0.89
15	213.81±20.83	11.99±1.89	9.42±0.96
16	215.58±27.85	11.85±1.01	9.85±1.03
17	211.15±38.02	10.24±0.53	10.09±0.33
18	137.23±34.45	11.65±0.72	10.36±0.68
19	135.87±35.11	11.95±1.37	10.66±0.52
20	134.51±23.35	12.25±0.56	10.96±0.91
Mean ±σ	184.90±40.92	11.50±0.78	10.20±0.71

Activity measurement in the cattle dung samples

The activity concentration of ^{40}K, ^{238}U and ^{232}Th in the dung samples range from 115.21 to 225.44 Bqkg^{-1} with a mean value of 184.90±40.92 Bqkg^{-1} for ^{40}K; 10.13 to 13.17 Bqkg^{-1} with a mean value of 11.50±0.78 Bqkg^{-1} for ^{238}U and 8.12 to

11.28 Bqkg^{-1} with a mean value of 10.20±0.71 Bqkg^{-1} for ^{232}Th (Table 4). The activity concentrations in cattle dung samples were higher than the corresponding values in the grass from the study area. This may be attributed to the ingestion of other sources of radionuclides such as the drinking water available to the cattle grazing in the study area. The activity concentrations of the radionuclides in water samples were reported to be significantly high in Agege (Ojo & Afolayan, 2013). The ^{40}K value of 218.6±66.0 Bqkg^{-1} obtained in Abeokuta was higher than that of the present study (Alausa *et al.,* 2015). However, the ^{238}U and ^{232}Th activity concentration values of 10.5±1.1 and 8.3±1.9 Bqkg^{-1} obtained in Abeokuta (Alausa *et al.,* 2015) were lower when compared to that obtained in the present study. The mean values for the differences between the dungs and grasses are 69.44±42.48 Bqkg^{-1} for ^{40}K; 1.44±0.68 Bqkg^{-1} for ^{238}U and 1.89±2.61 Bqkg^{-1} for ^{232}Th.

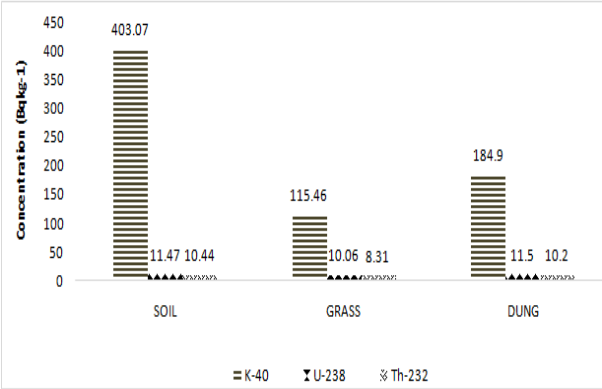

Fig. 2: Mean distribution of radionuclides in all samples

Soil to grass transfer factor

The plants take in deposited radionuclides from the soil, commonly expressed as soil-to-plant transfer factor (TF), which is widely used for determining the radiological effect. This parameter is an environmental transfer model, which is useful in the prediction of radionuclide concentration in plants/agricultural crops for estimating dose impact to human. Generally, the soil-to-plant transfer of radionuclides depends on soil type, pH, solid/liquid distribution coefficient, exchangeable K^+, and organic matter contents. The transfer factor TFs for ^{40}K, ^{238}U and ^{232}Th were determined and the results were presented in Table 5. The mean values of the transfer factors TFs were 0.29±0.05, 0.88±0.10 and 0.80±0.27 for ^{40}K, ^{238}U and ^{232}Th, respectively. The TFs values for ^{40}K in the samples were lower compared to that of ^{238}U and ^{232}Th. The TFs values for ^{232}Th in the grass samples were smaller than the values obtained for ^{238}U, this was in conformity with the result obtained from other literature (Alausa *et al.,* 2015). The values obtained in this study were higher than the range of values of 0.056 for ^{226}Ra, 0.089 for ^{232}Th and 0.275 for ^{40}K obtained for Bangladesh (Shyamal *et al.,* 2013). The values reported in Table 6 could be traced to other sources such as drinking water and feed given to cattle at the rearing field.

Table 5: Transfer ratio of ^{40}K, ^{238}U and ^{232}Th for soil to grass samples

Samples	TF (^{40}K)	TF (^{238}U)	TF (^{232}Th)
1	0.26	0.75	0.82
2	0.27	0.83	0.91
3	0.28	0.91	1.02
4	0.35	0.98	0.25
5	0.30	0.89	0.33
6	0.29	0.80	0.30
7	0.28	0.73	0.30
8	0.48	0.84	0.99
9	0.24	0.84	0.92
10	0.24	0.86	0.86
11	0.25	0.89	0.90
12	0.25	0.91	1.05
13	0.25	1.05	0.97
14	0.30	1.09	0.89
15	0.31	1.05	0.86
16	0.32	0.89	0.82
17	0.26	0.81	0.97
18	0.30	0.82	0.90
19	0.28	0.84	0.93
20	0.26	0.85	0.96
Mean ±σ	0.29±0.05	0.88±0.10	0.80±0.27

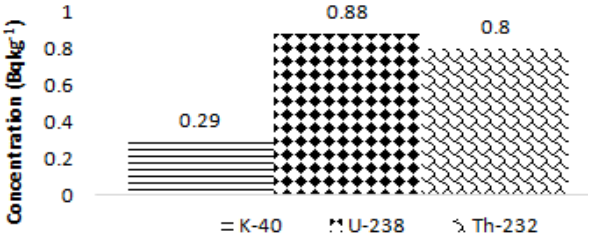

Fig. 3: Mean soil-grass transfer factor of radionuclides in samples

Table 6: Difference in the estimated activity concentration in dung and grass samples (concentration in dung – concentration in grass)

Samples	^{40}K (Bqkg^{-1})	^{238}U (Bqkg^{-1})	^{232}Th(Bqkg^{-1})
1	115.96	1.90	0.04
2	100.2	1.34	0.32
3	84.44	0.96	0.06
4	115.9	2.20	5.12
5	87.07	1.11	7.01
6	89.04	1.80	7.30
7	32.97	2.49	7.59
8	5.73	1.40	0.02
9	27.86	1.86	1.69
10	21.30	1.96	2.00
11	14.74	1.70	2.31
12	108.66	0.21	0.06
13	112.50	0.18	0.74
14	108.05	0.48	0.51
15	103.60	0.78	0.32
16	102.47	2.00	0.82
17	100.59	0.75	0.02
18	17.10	1.87	0.82
19	19.26	1.91	0.64
20	21.42	1.95	0.46
Mean ±σ	69.44±42.48	1.44±0.68	1.89±2.61

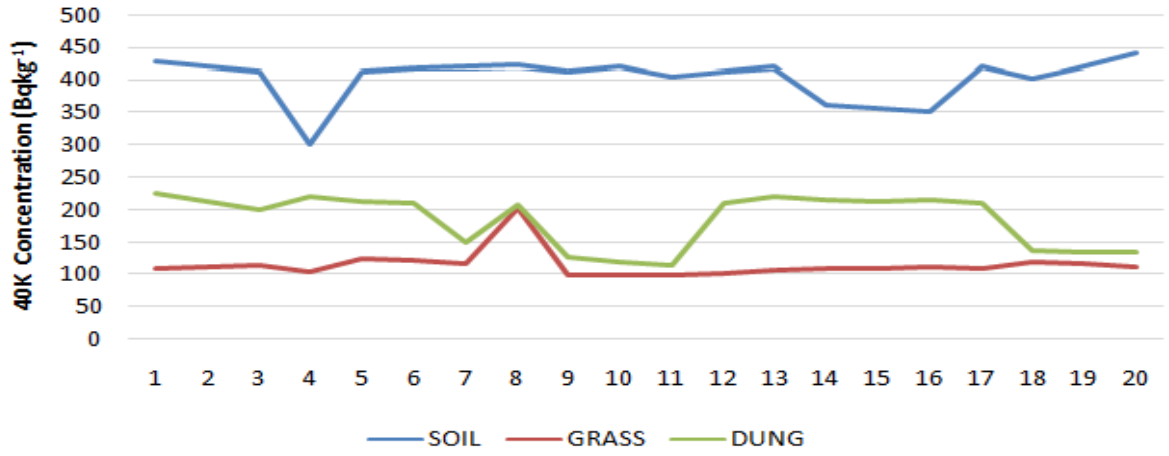

Fig. 4: Distribution of ^{40}K concentrations in soil, grass, and dung

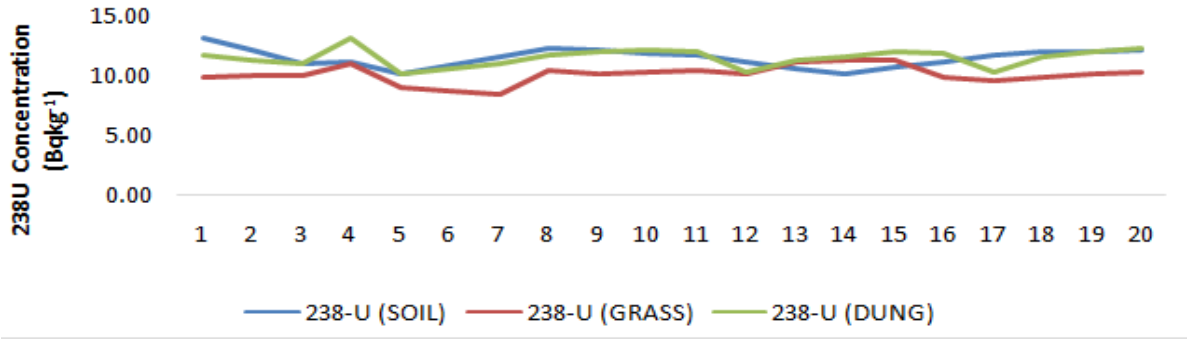

Fig. 5: Distribution of ^{238}U concentrations in soil, grass, and dung

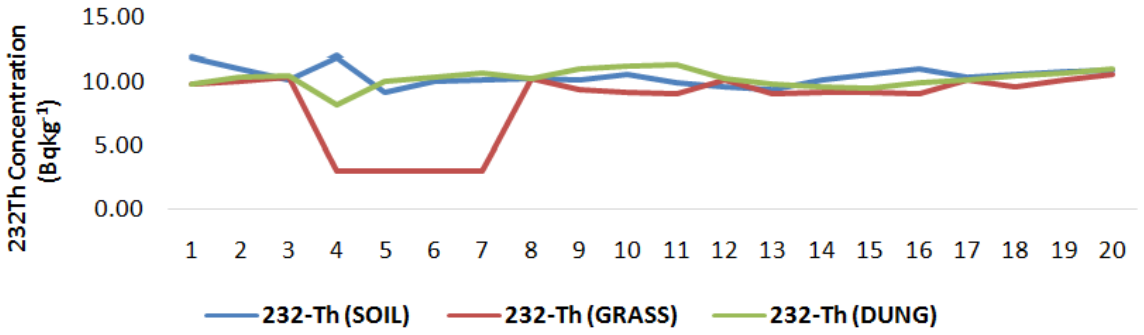

Fig. 6: Distribution of ^{232}Th concentrations in soil, grass, and dung

The mean radioactivity levels of 291.8±58.3 Bqkg^{-1} for ^{40}K; 11.7±0.8 Bqkg^{-1} for ^{238}U and 9.3±2.0 Bqkg^{-1} for ^{232}Th reported in grass samples reported for Abeokuta (Alausa *et al.*, 2015) were higher than the corresponding values in the present study. However, the ranges of activity concentration of the radionuclides are similar to the values obtained for Tehran-Iran (Hafezi *et al.*, 2005). The range of ^{40}K activity concentrations in the study was lower when compared to the values reported for some vegetables consumed in Jordan (Jamal, 2015). The activity concentrations in cattle dung samples were higher than the corresponding values in the grass from the study area and this may be attributed to the ingestion of other sources of radionuclides such as the drinking water available to cattle in the grazing area. The activity concentration of the radionuclides in water was reported to be high in Agege (Ojo and Afolayan, 2013).

The transfer factor values for ^{40}K in the samples were lower compared to that of ^{238}U and ^{232}Th. The transfer factor values for ^{232}Th in the grass samples were lower than the values obtained for ^{238}U; this was in conformity with the result obtained in other literature. The values obtained in this study were higher than the range of values obtained for Chittagong city of Bangladesh (Shyamal *et al.*, 2013).

The transfer factor indicated that only a fractional amount of the radionuclides was transferred from the soil to the grass in the study. The results obtained showed that Uranium concentrations in the grass samples from the study area have low concentrations compared to that of Thorium but Uranium has the highest transfer factor. This is because Uranium is relatively susceptible to be soluble whereas Thorium is easily absorbed by the soil. The study indicated a possible low radiological effect on human feeding on cattle beef in the study area when compared to that earlier reported for Abeokuta.

Conclusion

The activity concentration of ^{40}K, ^{238}U and ^{232}Th in the samples collected at cattle-rearing field area of Mangoro-Agege, Lagos Nigeria were measured using a well calibrated NaI(TI) and a well-shielded detector coupled to a computer resident quantum multichannel analyzer. The radioactivity distribution in all samples was shown in Tables 2-4 and the transfer factor of radionuclides from soil-to-grass in Table 5. The mean activity concentration of ^{40}K, ^{238}U and ^{232}Th for the present study were lower than the results obtained at a cattle-rearing field area of Alabata in Abeokuta, Ogun state Nigeria. The results obtained were however higher than some values obtained in some other literature. The activity concentrations of radionuclides in the soil were lower than the world average values. The soil samples exhibited the highest radioactivity levels followed by the cattle dung and the least was measured in the grass samples. It could be concluded that the cattle ingest radionuclides from other sources such as drinking water in the area that may constitute to the higher values in dung than grass; this is not in conformation with the study at Alabata cattle-rearing field. The transfer factor indicated that only a fractional amount of the radionuclides was transferred from the soil to the grass in the study area.

After carrying out the measurement of activity concentration of radionuclides in the samples collected from the study area, the result showed that the concentration in the cattle dung samples was higher than the concentration in the grass samples. Therefore, it is recommended that drinking water and feed is given to the cattle should be studied to ascertain the radioactivity levels in the water within the rearing field. This is to affirm sources of a higher level of radionuclides in the cattle dung than the grass.

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