A Baseline Investigation and Safety Assessment of Dump Sites in Ibadan and Environs, Nigeria.

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Abstract: The activity concentrations and radiation dose contributions due to three naturally occurring primordial radionuclides: K-40, U-238 and Th-232 in soil samples from selected dump sites in Ibadan and environs, Nigeria has been deduced. A baseline data has been obtained due to forensic investigation of selected dump sites and the average radiation dose contributions to the environment has been estimated. Activity concentration of K-40 was found in soil soil samples from dump sites in use ranged from 153.6+_ 17.4Bq/Kg to 315.0+_ 16.7Bq/Kg, with the highest found in location 2 (Lapite). The activity concentrations of U-238 ranged from 0.10+_17.1Bq/Kg to 48.1+_ 64.0Bq/Kg with the highest found in location 26 (Ajakanga). The activity concentration ranged fro 1.8+_17.8Bq/Kg to 252.7+_ 17.5Bq/Kg. The highest concentration of Th-232 was found in location 19 (Awotan) while the lowest was found in location 40 (Aba – eku). The average value of the total absorbed dose ratse for the use and abandoned dump sites are 31.0 +_ 44.0nGyh^{-1} and 32.0+_ 36.3nGyh^{-1} respectively. Fifty nine (59) sampled locations were within the safety limit with recommended world mean value of 13.5-69.8nGyh^{-1} by UNSCEAR while one location was above it.

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1.0 Introduction

Humans are exposed to ionizing radiation from numerous sources in the environment. Among them include the cosmic rays and natural radionuclide sources in air, food and drinking water (NCRP, 1976).

Primordial radionuclides have been found to exist since the earth was formed. The earth was formed about 6 x 10^9 years ago. Thus a primordial radionuclide needs at least a half life of 10^8 years to still be detectable today. The three most prominent ones till now are K-40, U – 238 and Th – 232. A large percentage of human exposure to ionizing radiation comes from natural origin, the major contributors being the naturally occurring radioactive elements of the uranium and thorium series, and the non-series radioactive potassium (Farai et al, 2003, 2005).

Due to the process of soil formation, these radionuclides find their way from the host rocks to the soil. The decay schemes of the various natural radionuclides also results to generation of their progeny which contribute to the natural background radionuclide in any geographical location.

Radiation sources also include anthropogenic or man-made sources. The major man-made radiation sources that result in exposure of members of the public are; tobacco, lantern, smoke, television, nuclear medicine detectors, medical x-ray, building materials etc.

IAEA (1986) estimate of dose contribution in the environment shows that 85% of doses are derived from the natural radionuclides while the remaining 15% is from cosmic rays and nuclear processes.

Radioactive waste are materials that contain or that are contaminated with radionuclides at concentrations or radioactivity levels greater than tolerance levels established by the appropriate regulatory authority and for which no use is foreseen.

Radioactive waste management is a process of disposing of waste in a way that safeguards the environment and the health of the public. In this sense, radioactive waste management is a tool of public health control and for applying policy on public exposure to the area of waste disposal.

In this study, we investigate the legal and illegal dumping of waste containing high concentrations of primordial radionuclides, inorder to determine the radiological significance of such dumping.

Thus, the purpose of this survey that was undertaken was to:

i. Survey sites for the possible presence of radioactive wastes due to improper disposal by users in Ibadan and environs.
ii. Establish a base line for radioactivity levels at these sites.

2.0 MATERIALS AND METHOD

2.1 STUDY AREA

The study area was Ibadan, Oyo State, the South Western Nigeria. A preliminary survey conducted revealed that Ibadan and its environs in Oyo State,Nigeria has four legal and many illegal dump sites, with the major legal dump sites located on the out skirts of Ibadan city. The names and location of the legal dump sites are:

- Lapite Dump Site: This is located beyond Moniya along Oyo road in Akinyele local government area.
- Awotan Dump Site: This is located in Apete in Ido local government area.
- Ajakanga Dump Site: This is located in Challenge area in Oluyole local government area.
- Aba-eku Dump Site: This is located in Akanran village in Ona Ara local government area.

Those that are not sanitary land fill based, regarded as illegal dump sites include: land opposite the federal high court at ring road, land near a major road at the Eleyele water works in Eleyele, land close to the Nigeria National Petroleum Corporation (NNPC) in Apata, Ajibode, Ojoo in Akinyele Local Government Area. These are abandoned dump sites.

Table 2.0: Dump Sites Survey

	Dump Site	Location	Official Status	No of Samples Collected	S/No of Soil Sample
1.	Lapite	Moniya, Akinyele LG	Legal (in use)	10	1-10
2.	Awotan	Apete, Ido LG	Legal (in use)	10	11-20
3.	Ajakanga	Challenge, Oluyole LG	Legal (in use)	10	21-30
4.	Aba-Eku		Legal (in use)	10	31-40
5.	Federal High Court	Ring Road, Oluyole LG	Illegal (Abandoned)	10	1-10
6.	Water Works	Eleyele, Ido LG	Illegal (Abandoned)	-	-
7.	NNPC	Apata LG	Illegal (Abandoned)	-	-
8.	Ajibode	Ojoo Akinyele LG	Illegal (Abandoned)	10	11-20

2.2 SAMPLE COLLECTION AND PREPARATION

The samples used for the work were soil samples collected from the four major legal dump sites and from two of the illegal dump sites in Ibadan. Ten samples were collected from each of the six areas, randomly spreading out the sample location as much as possible to ensure a good representation. The soil samples were collected from the dump sites by digging approximately, 10-15cm below the top soil as a good representation of what has been dumped over time. These samples were packed in polythene bags for easy conveyance.

The soil samples were air dried after collection. Next, after drying, they were sealed in cylindrical plastic containers. A total of sixty samples were packed for subsequent analysis.

The samples were stored for 28 days before counting in order to allow radioactive equilibrium to be reached between the parent primordial radionuclides and decay product radionuclides or progeny.

2.3 Counting Procedure

The counting procedure adopted was gamma spectroscopy A Sodium Iodide(Tallium-activated) coupled to a Canberra series 10 multi-channel analyzer was employed. The counting was done for a period of 36,000 seconds. The region of interest (ROI) setting was used to define the regions of interest for the expected radionuclides. Region one was photo-peak corresponding to the gamma energy 1.465 MeV from K-40, region two was the photo-peak energy 1.765MeV for U-238 and region three was the photo-peak of energy 2.615 MeV for Th-232. Each sample containing 200g of soil in sealed plastic container was placed on the detector inside a 5cm thick Canberra lead castle to shield the detector against environmental background for counting.

3.0 RESULTS AND DISCUSSION

The standard sample has a known concentration given by International Atomic Energy Agency (IAEA) as 479.15 Bq/Kg for K-40, 556.47 Bq/Kg for U-238 and 11.60 Bq/Kg for Th-232. The value of K was

determined for each radionuclide from its concentration and the area under the photo-peak obtained from the results of counting . The constant K was obtained as K_K=0.152, K_U=0.096, K_{Th}=0.052 from standard reference sources. The activity concentration was calculated for each of the radionuclides in the samples using the conversion factor K viz the equation: C = KA which relates the activity concentration, the photo-peak area and the activity.

Table 3.0: Activity concentration of soil samples

Locations	K-40 (Bq/kg)	U-238 (Bq/kg)	Th-232 (Bq/kg)
DUMP SITES IN USE			
1	203.0±17.5%	BDL	43.3±17.1%
2	315.7±16.7%	BDL	3.4±17.1%
3	303.0±17.1%	32.1±65.0%	24.6±16.8%
4	204.8±17.2%	40.0±64.3%	27.8±17.0%
5	262.3±17.0%	11.9±72.3%	BDL
6	249.9±17.3%	31.4±65.1%	13.0±17.1%
7	156.7±17.8%	38.6±64.8%	11.9±17.6%
8	213.9±17.0%	34.2±64.7%	8.5±17.3%
9	198.4±17.6%	11.3±71.4725%	BDL
10	157.3±18.0%	BDL	26.1±16.8%
11	206.5±17.4%	19.6±68.2%	20.7±16.8%
12	212.9±17.0%	19.2±68.7%	25.4±16.8%
13	256.4±17.0%	48.1±64.0%	72.6±16.5%
14	286.0±17.1%	16.2±69.5%	7.8±17.1%
15	189.8±17.4%	BDL	16.3±16.9%
16	250.4±17.2%	30.9±65.1%	BDL
17	171.4±17.3%	4.7±82.4%	35.6±16.6%
18	155.4±17.5%	9.7±74.6%	29.8±16.7%
19	224.0±17.0%	BDL	252.7±17.5%
20	281.9±17.2%	BDL	65.1±16.4%
21	187.5±17.4%	5.3±80.5%	23.7±16.8%
22	172.1±17.5%	43.4±63.5%	34.7±16.6%
23	155.1±17.8%	BDL	23.2±16.8%
24	283.7±17.2%	28.6±66.0%	23.4±16.8%
25	231.5±17.4%	BDL	2.5±17.4%
26	211.0±17.1%	0.1±92.1%	23.1±16.8%
27	200.9±17.4%	BDL	23.2±16.8%
28	277.6±16.8%	0.4±77.0%	BDL
29	192.5±17.0%	4.9±81.8%	16.2±17.0%
30	245.3±17.1%	BDL	18.7±16.9%
31	276.7±17.2%	17.3±69.6%	15.4±16.9%
32	158.2±16.9%	23.1±67.3%	27.0±16.7%
33	236.4±17.1%	8.2±76.7%	18.6±16.9%
34	153.7±17.4%	19.9±68.0%	18.1±16.8%
35	265.2±17.2%	BDL	0.3±17.3%
36	304.5±17.3%	4.91±80.9%	5.7±16.8%
37	240.2±17.1%	BDL	6.4±17.1%
38	307.8±17.2%	9.6±74.8%	5.3±17.2%
39	155.4±17.6%	8.1±76.7%	BDL
40	157.8±7%	BDL	1.8±17.9%
ABANDONED DUMP SITES			
1	218.6±17.0%	9.2±75.8%	31.2±16.6%
2	296.2±16.9%	28.1±60.6%	41.0±16.6%
3	319.4±17.1%	35.9±64.5%	37.3±16.6%
4	272.2±16.9%	27.1±66.3%	BDL
5	277.8±16.2%	9.4±75.7%	27.0±16.8%

6	290.7±16.9%	20.0±69.0%	25.4±16.8%
7	278.3±17.0%	24.4±67.3%	38.3±16.6%
8	239.9±17.3%	21.1±68.2%	30.1±16.7%
9	219.41±17.0%	20.7±67.6%	BDL
10	276.7±16.9%	1.1±89.0%	20.2±18.3%
11	194.7±17.2%	18.8±68.0%	18.3±16.9%
12	295.1±16.8%	0.3±90.7%	BDL
13	246.7±16.9%	7.1±78.2%	19.1±16.9
14	314.7±17.1%	BDL	10.3±17.1%
15	195.6±17.0%	3.6±84.4%	26.9±16.7%
16	319.1±16.7%	24.6±66.7%	10.5±17.1%
17	295.7±17.1%	9.1±75.0%	7.3±17.1%
18	185.7±17.0%	2.9±84.9%	9.3±17.1%
19	318.3±17.1%	30.0±66.0%	46.6±16.6%
20	156.1±17.3%	33.2±64.9%	31.0±16.7%

Note :BDL = Below the Detection Limit

The absorbed dose rate, at a height of 1m above the ground due to the concentrations of K-40, U-238 and Th-232 in the soil in each of the locations in Ibadan was calculated using equation 1.0 below (Beck et al, 1972).

$$D=0.042C_k + 0.429C_u + 0.666C_{Th} \quad \ldots\ldots\ldots\ldots\ldots 1.0$$

where D is the total absorbed dose rate in nGy/hr, C_K , C_U and C_{Th} are the activity concentrations in Bq/Kg of K-40, U-238 and Th-232 respectively. The calculated total absorbed dose rates are given in Table 3.1 and presented for
each of the 60 samples.

Table 3.1: The absorbed dose rate in the sample due to K-40, U-238 and Th-232.

Locations	K-40	U-238	Th-232	Total Absorbed dose $nGyh^{-1}$
DUMP SITES IN USE				
1	8.5±17.5%	BDL	28.8±17.1%	37.3
2	13.3±16.7%	BDL	2.3±17.1%	15.5
3	12.7±17.1%	13.8±65.0%	16.6±16.8%	43.1
4	8.6±17.2%	17.2±64.3%	18.5±17.0%	44.3
5	11.0±17.0%	5.1±72.3%	BDL	16.1
6	10.5±17.3%	13.5±65.1%	8.7±17.1%	32.7
7	6.6±17.8%	16.5±64.8%	7.9±17.6%	31.1
8	9.0±17.0%	14.7±64.7%	5.6±17.3%	29.3
9	8.3±17.6%	4.8±71.5%	BDL	13.2
10	6.6±18.0%	BDL	17.4±16.8%	24.0
11	8.7±17.4%	8.4±68.1%	13.8±16.8%	30.9
12	8.9±17.0%	8.2±68.7%	16.9±16.8%	34.1
13	10.8±17.0%	20.6±64.0%	48.4±16.5%	79.8
14	12.0±17.1%	6.9±69.5%	5.2±17.1%	24.1
15	8.0±17.4%	BDL	10.9±16.9%	18.8
16	10.5±17.2%	13.2±65.1%	BDL	23.7
17	7.2±17.4%	2.0±82.4%	23.7±16.6%	33.0
18	6.5±17.5%	4.2±74.6%	19.8±16.7%	30.5
19	9.4±17.0%	BDL	168.3±17.5%	177.7
20	11.8±17.2%	BDL	43.4±16.4%	55.2
21	7.9±17.4%	2.3±80.5%	15.8±16.8%	25.9
22	7.2±17.5%	18.6±63.5%	23.1±16.6%	48.9
23	6.5±17.8%	BDL	15.4±16.8%	21.9
24	11.9±17.2%	12.3±66.0%	15.6±16.8%	39.8

25	9.7±17.4%	BDL	1.7±17.4%	11.4
26	8.9±17.1%	BDL	15.45±16.8%	24.3
27	8.4±17.4%	BDL	15.4±16.8%	23.9
28	11.7±16.8%	0.2±77.0%	BDL	11.8
29	8.1±17.0%	2.1±81.8%	10.8±17.0%	21.0
30	10.3±17.1%	BDL	12.5±16.9%	22.8
31	11.6±17.2%	7.4±69.6%	10.2±16.9%	29.3
32	6.6±16.9%	9.9±67.3%	18.0±16.7%	34.6
33	9.9±17.1%	3.5±76.7%	12.4±16.9%	25.8
34	6.5±17.4%	8.5±68.0%	12.1±16.8%	27.0
35	11.1±17.2%	BDL	0.2±17.3%	11.3
36	12.8±17.3%	2.1±80.9%	3.8±16.8%	18.7
37	10.1±17.1%	BDL	4.39±17.1%	14.4
38	12.9±17.2%	4.1±74.8%	3.5±17.2%	20.6
39	6.5±17.6%	3.5±76.7%	BDL	10.0
40	6.6±17.7%	BDL	1.2±17.9%	7.8
ABANDONED DUMP SITES				
1	9.2±17.0%	3.9±75.8%	20.8±16.6%	33.9
2	12.4±16.9%	12.0±60.6%	27.3±16.6%	51.8
3	13.4±17.1%	15.4±64.5%	24.9±16.6%	53.7
4	11.4±16.9%	11.6±66.3%	BDL	23.1
5	11.7±16.2%	4.1±75.7%	18.0±16.8%	33.7
6	12.2±16.9%	8.6±69.0%	16.9±16.8%	37.7
7	11.7±17.0%	10.5±67.3%	25.5±16.6%	47.6
8	10.1±17.3%	9.1±68.2%	20.0±16.7%	39.2
9	9.2±17.0%	8.9±67.6%	BDL	18.1
10	11.6±16.9%	0.5±89.0%	13.5±18.3%	25.5
11	8.2±17.2%	8.1±67.9%	12.2±16.9%	28.4
12	12.4±16.8%	0.1±90.7%	BDL	12.5
13	10.4±16.99%	3.1±78.2%	12.7±16.9%	26.1
14	13.2±17.1%	BDL	6.8±17.1%	20.0
15	8.2±17.0%	1.5±84.4%	17.9±16.7%	27.6
16	13.4±16.7%	10.5±66.7%	7.0±17.1%	31.0
17	12.4±17.1%	3.9±75.0%	4.9±17.1%	21.2
18	7.8±17.0%	1.2±84.9%	6.2±17.1%	15.3
19	13.4±17.1%	12.9±66.0%	31.0±16.6%	57.3
20	6.6±17.3%	14.2±65.9%	20.6±16.7%	41.4

4.0 FURTHER DISCUSSION

The measurement of radioactivity in soil samples from dump sites in Ibadan, revealed that the naturally occurring radionuclides present in the dump sites are K-40, U-238 and Th-232 and their progeny.

Activity concentrations of K-40 found in soil samples from dump sites in use ranged from 153.6±17.4Bq/kg to 315.± 16.7Bq/kg, with the highest found in location 2 (Lapite) whereas the lowest was in location 34 (Aba eku). The activity concentrations of U-238 ranged from 0.10±17.1Bq/kg to 48.1±64.0Bq/kg with the highest found in location 13 (Awotan) and the lowest found in location 26 (Ajakangan). The activity concentrations of Th-232 ranged from 1.8±17.8Bq/kg to 252.7±17.5Bq/kg. The highest concentration of Th-232 was found in location 19 (Awotan) whereas the lowest was found in location 40 (Aba eku).

The activity concentration of K-40 found in soil samples from abandoned dump sites ranged from 156.1±17.3Bq/kg to 319.4±16.9Bq/kg with the highest found in location 2 (Federal High Court, Ring Road) and the lowest was found in location 20 (Ajibode Ojoo). The activity concentrations of U-238 ranged fom 0.3±16.8Bq/kg to 35.9±64.5Bq/kg. The highest concentration of U-238 was found in location 3 (Federal High Court, Ring Road) while the lowest was found in location 12 (Ajibode Ojoo). The activity concentration of Th-232 ranged from 7.3±17.1Bq/kg to 46.6± 16.6Bq/kg with the highest concentration found

in location 19 (Ajibode Ojoo) and the lowest was found in location 17 (Ajibode Ojoo).

The total absorbed dose rate of soil samples from dump sites in use ranged from 7.8±43.0 nGy h^{-1} to 177.7±80.0 nGy h^{-1} with the highest found in location 19 and the lowest in location 40. These locations are Awotan in Ido-local government Apete and Aba-eku in Ona-ara local government in Akanran respectively.

Also, the total absorbed dose rate of the soil sample from abandoned dump sites ranged from 12.5±41.0 $nGyh^{-1}$ to 57.3± 33.0 $nGyh^{-1}$. The highest absorbed dose was found in location 19 and the lowest was found in location 12. These two locations are in the dump sites in Oluyole local government area, Ring Road.

The average value of the total absorbed dose rate for the use and abandoned dump sites are 31.0±44.0 $nGyh^{-1}$ and 32.0±36.3$nGyh^{-1}$ respectively. Fifty nine (59) sampled locations were within the safety limit recommended world mean value of 13.5-69.8$nGyh^{-1}$ by UNSCEAR except one location was above it.

5.0 CONCLUSION

In conclusion, the three naturally occurring radionuclides detected in soil samples from dump sites in use and abandoned dump sites are potassium -40 (K-40), Uranium-238 (U-238) and Thorium-232 (Th-232). K-40 was fairly evenly distributed whereas U-238 and Th-232 were unevenly distributed over all the site locations for the two types of dump sites highlighted in the study.

The only location revealed to be above the standard mean value by the UNSCEAR was Aba-eku in Ona Ara local government, Akanran. The natural radioactivity contents of soil samples from dump sites give dose rates that are comparable to those in a survey of terrestrial gamma radiation dose level in Ibadan, Nigeria (Farai et al,2000).

The absorbed dose rate was found to be (0.075±0.011) $nGyh^{-1}$. A study on population dose distribution due to soil radioactivity concentration level in 18 cities across Nigeria (Obed et al, 2005) revealed that the absorbed dose rate in air across the cities was in 9.88. The range 19.0±5.0 and 88.0±44.0 nGy h^{-1} and gross mean value was 42.0±21.0 $nGyh^{-1}$.

The present survey undoubtedly yields data that provides useful information that may be used to detect or predict future occurrence of radiation accident in the dump site environment.

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