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Assessment of Natural Radionuclides Level in Wasteland Soils around Olusosun Dumpsite Lagos, Nigeria.

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Abstract: *The natural radionuclide level in wasteland soil around Olusosun dumpsite Ojota, Nigeria were measured using a highly shielded Canberra Na(Tl) detector, a type of gamma-ray spectrometer. A total of 30 samples (15 from active site and 15 from dormant site) were analyzed. The mean value of ^{238}U, ^{232}Th and ^{40}K concentrations determined for soil samples from the active dumpsite were 69.69 ± 19.10 Bqkg^{-1}, 14.49 ± 3.22 Bqkg^{-1} and 409.44 ± 86.08 Bqkg^{-1} respectively. For the soil samples from the dormant dumpsite, the mean value of ^{238}U, ^{232}Th and ^{40}K concentrations were 61.25 ± 21.82 Bqkg^{-1}, 12.08 ± 1.74 Bqkg^{-1} and 345.98 ± 56.92 Bqkg^{-1} respectively. The mean value of ^{238}U, ^{232}Th and ^{40}K concentrations for soil samples from both the active and dormant dumpsites were higher than the permissible global values of 52.2 Bqkg^{-1}, 41.0 Bqkg^{-1} and 230.0 Bqkg^{-1} respectively by UNSCEAR. The mean annual effective dose obtained for soil sample from active dumpsite is 0.2767 while 0.2550 was obtained for soil samples from the dormant dumpsites. Both were found to be below the recommended standard by UNSCEAR. All the soil samples analyzed for both the active and dormant dumpsites met the safety criteria by UNSCEAR and hence do not pose any radiological hazards to human health. However, the result of statistical analysis (ANOVA) showed that there is significant difference between the result of the annual effective dose for the active soil samples and the dormant soil samples*

Keywords*; Radionuclides, Olusosun wasteland, domant, active, landfill, dumpsite.*

I. Introduction

Man is continuously exposed to ionizing radiation from Naturally Occurring Radioactive Materials (NORM). The origin of these materials is the earth crust, but they find their way into soil, building materials, air, water, food and the human body itself. In many parts of the world, building materials containing radioactive materials have been used for generations. As individuals spend more than 80% of their time indoor, the internal and external radiation exposure from building materials creates prolonged exposure situation (ICRP, 1999). The Earth is naturally radioactive, and about 90% of human radiation exposure arises from natural sources such as cosmic radiation, exposure to radon gas and terrestrial radionuclides (Lee et al., 2004). However, it has been observed that the type and concentration vary considerably depending on the soil type. The effects of the radiation emitted by different radionuclides depend on the overlining soil material (thickness and type), its chelating agents and physio-chemical properties (Believermis et al, 2009). Investigation has shown that natural radioactivity and the associated exposure due to gamma radiation (i.e from radionuclides) depend primarily on geology (i.e soil type). Natural in soil constitute a significant component of the background exposure sources of the population.

Solid waste other than hazardous or radioactive material are often referred to as Municipal Solid Waste (MSW). Municipal Solid Waste is useless unwanted material discharged as a result of human activity. Human activity create wastes and it is the way this paper are handled, stored, collected and disposed of, that constitute risk to the environment and public health. In the urban area especially the rapidly urbanizing cities of the developing world, problems and issues of solid waste management are of immediate importance. This has been acknowledge by most governments. However, rapid population growth of most municipal authorities to provide even the basic services when waste are collected. They are disposed of in uncontrolled dumpsites and/or burnt, polluting water resources and air (Onibokun et al, 2000). MSW includes waste generated from residential, commercial industrial, institution, construction, demolition process and municipal services. Residential single and multifamily dwellings, generate food waste, paper, cardboard, plastic, textiles, leather, yard waste , wood, glass metals, ashes, special waste and household hazardous wastes, commercial stores, hotels, restaurants etc (Tchobanoglous et al, 1993).

The practice of landfill system as a method of waste disposal in many developing countries is usually far from standard recommendations (Mull, 2005; Adewole, 2009). A standardised landfill system involves carefully selected location, and are usually constructed and maintained by means of engineering techniques,

ensuring minimized pollution of air, water and soil and risks to man and animals. Land filling involves 'placing' wastes in lined pit or a mound (sanitary landfills) with appropriate means of leachate and landfill gas control (Alloway and Ayres, 1997). In most cases however, 'landfill' in developing countries' context is usually an unlined shallow hollow (often not deeper than 50 cm). Zurbrugg et al. (2003) referred to it as 'dumps' which receive solid wastes in a more or less uncontrolled manner, making a very uneconomical use of the available space and that which allows free access to waste pickers, animals and flies, and often produce unpleasant and hazardous smoke from slow-burning fires. Besides, instances have been shown that revealed that even the lined (protected) landfills have been inadequate in the prevention of groundwater contamination (Lee and Lee, 2005).

In Nigeria, open dump is almost the verily available option for solid waste disposal, even in the capital cities. Sanitary landfill, however, is rare and unpopular, except perhaps among few institutions and few affluent people. Financial and institutional constraints are the immediate identifiable reasons for this in Nigeria and some other developing countries, especially where local governments are weak or underfinanced and rapid population growth continues (Nnuan, 2000; Elaigwu et al., 2007).

Lagos state Government, Nigeria still endorse the use of open space dumping and three official dumpsites are in use in Lagos metropolis namely, Olusosun, Abule-Egba and Solus. Of all these dumpsites, Olusosun is the most active in terms of traffic and quantity of waste recovery daily at the dumpsite (odunaiya, 2000). This method is regarded as primitive, as most developed countries consider waste as a source of wealth and investment in its treatment and disposal. Hazardous wastes are not separated from Municipal Solid Waste disposed of at the Olusosun dumpsite. The infections medical waste, toxic industrial solid wastes and domestic wastes are disposed together (Odunaiya, 2002). The soil is the primary recipient of solid waste (Nyle and Ray, 1999),. Millions of tons of these wastes from a variety of sources; industrial, domestic, agricultural find their way unto the soil. These wastes und up interacting with the soil system thereby changing the physical and chemical properties (Piccolo and Mbagwu, 1997). The accumulation of contaminants is aided by the capacity of soil to bind with clay minerals and organic substances. Their accumulation has multiple effects on the usability and functions of soil in the ecosystem.

II. Materials And Method

2.1 Study Area

The study was carried out in Ojota area of Lagos State in Nigeria. The area covers Ikosi Ketu, Oregun industrial estates, the commercial area of Kudirat Abiola way, Ojota residential area and LAWMA dumpsite (Figure 1), known as Olusosun landfill (Bello, 2002). The landfill is located between 6°23'N; 2°42'E and 6°41'N; 3°42'E. It is the largest of all the landfills in Lagos area; it has received more than 50% of the total refuse in Lagos area since 1989. As at the period when the dumpsite was created, the area (Ojota) was almost a vacant land (Bello, 2002). The area is however a flourishing commercial central district in Lagos State. The site of the landfill is about 10 km South East of Ikeja Local Government Area (LGA). Ikeja is the capital city of Lagos State. The state is the most flourishing Nigerian commercial arena, with a population of more than 9, 013, 534 and an annual growth rate of 3.2% (NPC, 2006). Soil samples from the active and the dormant dumpsites were taken for investigation of the radionuclides level present in them.

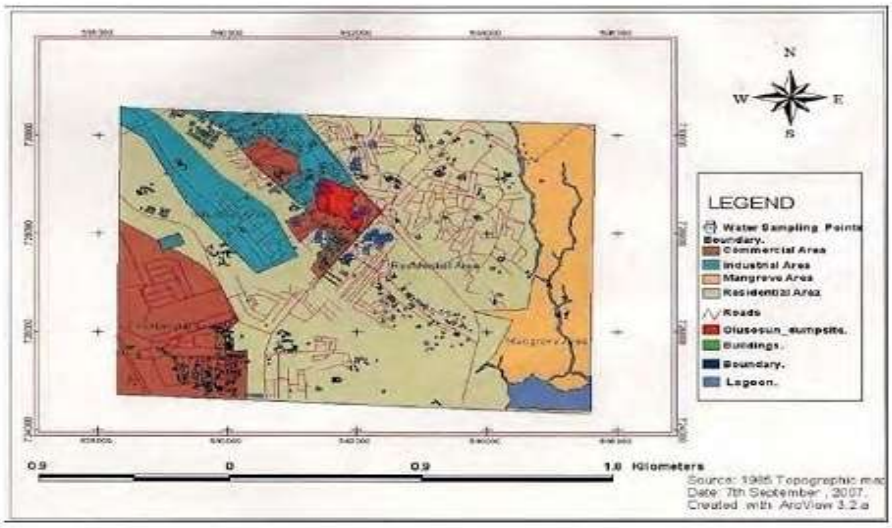

Figure 1 The landuse of the study area as shown on Landsat ETM+ of 2006 imageries.

2.2 Sample Preparation

In this study, 30 soil samples of different wasteland soil (15 dormant and 15 active) were used, they were collected randomly at various point, 20 metre away from each other from the sampling location (Olusosun landfill located in Ojota, Lagos State, southwestern Nigeria).

The soil samples were collected, air-dried, crushed and made to pass through a 0.5mm mesh sieve. These soil samples were stored in cylindrical air-tight containers and the containers were labeled and sealed. These samples were then left for about four (4) weeks before counting in order to attain a state of secular radioactive equilibrium after their progeny (Veiga et al., 2006). Then the samples were analyzed to determine the radionuclide concentration in the samples.

2.3 Measurement

In this analysis, gamma ray spectroscopy method was adopted. The spectrometer used for gamma counting consists of a highly-shielded Canberra NaI(Tl) detector enclosed in a 100mm thick lead blocks coupled to a Canberra Multichannel Analyzer (MCA) with a PC via an interface. The collector is located in the centre of the lead shield in order to minimize the effect of scattered radiation from the shield [20].

The Energy and Efficiency calibration of the gamma spectrometer were carried out using the International Atomic Energy Agency (IAEA) reference source material.

Accurate energy and efficiency of the gamma spectroscopy system were made quantity radionuclides present in the sample since the accuracy of all quantitative results depend on the attainable accuracy of the systems calibration.

The transition line of 1460 keV for ^{40}k, 1764 keV for ^{214}Bi and 2614 keV of ^{208}Ti were used to determine the concentration ^{40}K, ^{238}U and ^{232}Th respectively.

Finally, counting was carried out for a period of 36000s, first with an empty Marinelli beaker of identified geometry as the sample to determine the background spectrum. Thereafter, the sealed samples of cement were counted for the same period of 36000s.

The activity concentrations of the samples were determined using the total net counts under the selected photopeaks, the measured photopeak efficiency, gamma intensity and mass of the samples. After correcting for background and Compton contribution, the activity concentrations of ^{232}Th, ^{226}Ra and ^{40}K were determined. Equation 1 gives the relationship between the concentration A_C and other parameters.
Where; C is the net peak counts.

$$A_C = \frac{C_{net}}{I_\lambda \times E_{ff}(E_\lambda) \times m}$$

……..(1)

Where C_{net} is the net peak counts.
I_γ is absolute gamma decay intensity for the specific energy photopeak (including the decay branching ratio information).
$E_{ff}(E_\gamma)$ is the absolute efficiency of the detector at this energy and m is the mass of the sample in kg.

III. Result And Discussion

The photopeaks observed with regularity in the sample were identified to belong to the natural radioactive decay series headed by ^{238}U and ^{232}Th and as well as the singly occurring natural radionuclide ^{40}K. Although, other radionuclides if present appeared rather infrequently at low levels or occurred at levels below the minimum detectable limits (MDL).

Table 1 shows the summary of the radionuclide concentrations determined for the active site soil samples. The mean specific activities determined for ^{238}U, ranged between 51.92 and 96.76 Bqkg^{-1} with a mean value of 69.69 ± 19.10 Bqkg^{-1}. Also the specific activities for ^{232}Th ranged from 12.53 to 20.01 Bqkg^{-1} with a mean value of 14.49 ± 3.22 Bqkg^{-1} while those for ^{40}K, ranged from 302.33 to 496.04 Bqkg^{-1} with a mean value of 401.44 ± 86.08 Bqkg^{-1}. Similarly, Table 3 also shows the summary of the radionuclide concentrations determined for the dormant site soil samples. The mean specific activities determined for ^{238}U, ranged between 32.92 and 89.42 Bqkg^{-1} with a mean value of 61.25 ± 21.82 Bqkg^{-1}. Also the specific activities for ^{232}Th ranged from 10.03 to 14.28 Bqkg^{-1} with a mean value of 12.08 ± 1.74 Bqkg^{-1} while those for ^{40}K, ranged from 288.51 to 421.32 Bqkg^{-1} with a mean value of 345.98 ± 56.92 Bqkg^{-1}.

Table 2 shows the radium equivalent activity, absorbed dose rate and annual effective dose for the active site soil samples. The radium equivalent activity (Ra_{eq}) was also calculated since it gives a single index to describe the gamma output from different mixtures of radium, thorium and potassium in the material. The Ra_{eq} is calculated by the equation described by Beretka et al (1985) and Yang et al (2005) . The equation is stated in equation 2

$Ra_{eq} = C_{Ra} + 1.43\,C_{Th} + 0.077\,C_K$ …… (2)

Where $C_{Ra,}$ C_{Th} and C_K are the activity concentrations in $Bqkg^{-1}$ of ^{226}Ra, ^{232}Th and ^{40}K respectively.

The Ra_{eq} values calculated for the soil samples in Table 2 from the active dumpsite vary between 109.33 and 138.13 $Bqkg^{-1}$ with a mean value of 121.31 $Bqkg^{-1}$. For the soil samples from dormant dumpsite, Ra_{eq} value vary between 76.76 and 117.39 $Bqkg^{-1}$ with a mean value of 105.16 $Bqkg^{-1}$ as shown in Table 4. These values are smaller than suggested maximal admissible value of 370 $Bqkg^{-1}$ which is equivalent to an annual dose of 1.5 mSv but the European Commission report set the limit as 0.3 – 1.0 $mSvy^{-1}$ for safe use (European Commission, 1999; Flores eta, 2005; OECD,1979).

Moreover, to provide a characteristic of the external gamma ray, the absorbed dose rate D in air at about 1m above the ground was calculated using equation 3 (UNSCEAR, 2000; Veeiga et al., 2006).

$D(nGyh^{-1}) = 0.462C_{Ra} + 0.604C_{Th} + 0.0417C_K$ …… (3)

Where C_{Ra}, C_{Th} and C_K have the same meaning as in equation (1). The absorbed dose rate for the active dumpsite soil sample ranged from 50.87 to 63.71 $nGyh^{-1}$ with a mean value of 50.40 $nGyh^{-1}$ as indicated in Table 2. Also, the absorbed dose rate for the dormant dumpsite soil soil ranged from 35.75 to 57.86 $nGyh^{-1}$ with a mean value of 48.73 $nGyh^{-1}$ as indicated in Table 4. The values are less than the global average of 55 $nGyh^{-1}$ (UNSCEAR, 2000).

In order to assess the health effect due to the absorbed dose rate, the annual effective dose rate (E) was determined. The calculation was made by using the conversion coefficient of 0.7 $SvGy^{-1}$ and the outdoor occupancy factor of 0.2 as described in equation 4

$E(mSvy^{-1}) = D(nGyh^{-1}) \times 8760(hy^{-1}) \times 0.2 \times 0.7(SvGy^{-1}) \times 10^{-6}$ …… 4

The E values obtained for the soil samples from the active dumpsite ranged from 0.2495 to 0.3125 $mSvy^{-1}$ with a mean value of 0.2767 $mSvy^{-1}$ as indicated in Table 2. For soil samples from the dormant dumpsites, the E value ranged from 0.1754 to 0.2838 $mSvy^{-1}$ with a mean value of 0.2550 $mSvy^{-1}$ as indicated in Table 4. When compare with UNSCEAR (2000) limit of 0.460 $mSvy^{-1}$ for terrestrial radionuclides for area of normal background radiation, it is evident that the data obtained for both soil samples give a lower value.

Table 1: Radionuclide Content for the Active Dumpsite Soil Samples

Sample	238U (Bq/kg)	232 Th (Bq/kg)	40K (Bq/kg)
A1	61.90 ± 3.12	14.65 ± 2.90	411.32 ± 9.85
A2	82.16 ± 2.79	12.79 ± 2.81	475.23 ± 21.94
A3	55.69 ± 4.81	20.01 ± 2.61	325.36 ± 10.00
A4	96.76 ± 2.52	12.65 ± 1.85	302.33 ± 7.02
A5	51.92 ± 2.48	12.35 ± 1.83	496.04 ± 6.82
Mean Value	**69.69 ± 19.10**	**14.49 ± 3.22**	**401.44 ± 86.08**
World Range	**17-60**	**11-64**	**140-850**

Table 2: Radium Equivalent Activity, Absorbed Dose Rate and Annual Effective Dose for the Active Dumpsite Soil Samples

Active Soil Samples	Radium Equivalent Activity (R_{eq}) ($Bqkg^{-1}$)	Absorbed Dose Rate ($nGyh^{-1}$)	Annual Effective Dose ($mSvy^{-1}$)
A1	114.52	53.59	0.2629
A2	137.02	63.71	0.3125
A3	109.33	50.87	0.2495
A4	138.13	62.63	0.3072
A5	107.54	51.21	0.2512
Mean Value	**121.31**	**56.40**	**0.2767**

Table 3: Radionuclide Content for the Dormant Dumpsite Soil Samples

Sample	238U (Bq/kg)	232 Th (Bq/kg)	40K (Bq/kg)
B1	32.92 ± 5.32	14.28 ± 1.93	304.18 ± 7.46
B2	48.31 ± 1.98	11.62 ± 2.05	421.32 ± 18.62
B3	73.08 ± 3.72	10.03 ± 2.94	389.17 ± 9.36
B4	62.53 ± 2.81	13.43 ± 1.92	326.73 ± 5.52
B5	89.42 ± 3.12	11.08 ± 1.26	288.51 ± 13.85
Mean Value	**61.25 ± 21.82**	**12.08 ± 1.74**	**345.98 ± 56.92**
World Range	**17 – 60**	**11 – 64**	**140 – 850**

Table 4: Radium Equivalent Activity, Absorbed Dose Rate and Annual Effective Dose for the Dormant Dumpsite Soil Samples

Dormant Soil Samples	Radium Equivalent Activity (R_{eq}) ($Bqkg^{-1}$)	Absorbed Dose Rate ($nGyh^{-1}$)	Annual Effective Dose ($mSvy^{-1}$)
B1	76.76	35.75	0. 1754
B2	97.36	46.16	0.2264
B3	117.39	54.38	0.2668
B4	103.95	49.49	0.2428
B5	105.16	57.86	0.2838
Mean Value	**100.12**	**48.73**	**0.2550**

Furthermore, variations in the annual effective dose for the active and dormant soil samples were subjected to test of significance. Using the analysis of variance (ANOVA), the result of statistical analysis (Table 5) however showed that there is significant difference between the result of the annual effective dose for the active soil samples and the dormant soil samples on since p-value is greater than 0.05 at the level of significance α (= 0.05), indicating the rejection of null hypothesis (H) stating that there is no significant difference between the result of the annual effective dose for the active soil samples and the dormant soil samples.

Table 5: ANOVA Result for the Annual Effective Dose for Active and Dormant Soil Samples

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
ACTIVE	5	1.1952	0.2767	5.91E-05
	0	0	0	0
DORMANT	5	1.3833	0.2550	0.00011

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.000221	2	0.00011	1.142861	0.371953	4.737414
Within Groups	0.000677	7	9.66E-05			
Total	0.000897	9				

IV. Conclusion

The measurements of the natural radionuclide content of soil samples from active and dormant dumpsites were undertaken by means of gamma-ray spectrometry using a well shielded and well calibrated Canberra Na (Tl) detector coupled to a Canberra Multichannel Analyzer (MCA).

The results of the natural radionuclide concentrations obtained for ^{238}U, ^{232}Th and ^{40}K in the 10 samples from both the active and dormant dumpsites analyzed were lower than the permissible global value by UNSCEAR.

The radium equivalent activity and the annual effective dose rate were calculated to determine the radiological implication of these soil samples. All the soil samples (for the active and dormant dumpsites) analysed met the safety requirements. The result of statistical analysis (ANOVA) showed that there is significant difference between the result of the annual effective dose for the active soil samples and the dormant soil samples.

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