Sci.Int.(Lahore),28(2),1883-1887,,2016 ISSN 1013-5316;CODEN: SINTE 8

RADIOACTIVITY AND RADIOLOGICAL IMPACT ASSESSMENT IN OTA-DUMPING SITE, OGUN STATE, NIGERIA

M. Omeje[*], H. Wagiran, E.S Joel, O. T Kayode, O.O Adewoyin
[a,b,c,d]Department of Physics, Covenant University Ota, Ogun State, Nigeria
[b]Department of Physics, Faculty of Science, Universiti Teknologi Malaysia, 81310, Skudai, Johor, Malaysia
[*]Corresponding author's e-mail address - maxwell.omeje@covenantuniversity.edu.ng

ABSTRACT: *Background radiation levels and distributed radionuclides in Ota-dumping site were conducted in different stations to determine the concentrations of natural radionuclides and their possible radiological effects. The external gamma absorbed dose rate and concentration of radionuclides in the area were measured using portable hand-held plastic scintillometer (RS-125 Radiation detector). The activity concentrations vary from 2.47 ± 0.3 to 25.01 ± 1.0 BqK^{-1}, 12.49 ± 0.8 to 105.97 ± 0.6 BqK^{-1} and 15.65 ± 0.2 to 46.95 ± 0.2 BqK^{-1} for ^{238}U, ^{232}Th and ^{40}K respectively. The highest activity value of ^{238}U, ^{232}Th and ^{40}K reported in stations 11, 12 and 7 respectively. The absorbed gamma dose rates exposed to people in the area varies from 12.65 ± 2.2 to 44.45 ± 6.6 nGry^{-1} with the highest value of 44.45 ± 6.6 nGry^{-1} noted 50 m away from the site at station 12. This could be attributed to the effect of geological features and dose rates from the dumping site tilted towards the Northeast Southwest. The annual effective dose, radium equivalent activity and external hazard index exposed to people in the area are 0.055 mSvy^{-1}, 52.22 ± 0.6 BqK^{-1} and 0.4 respectively. All the values of radiological risks are within the recommended level by [18], but suggest that the inhabitants residing south western (SW) part of area should adjust if possible 500 m away from the dump-site to avoid long term accumulation which could pose cancer risk.*

Keywords: background radiation, radionuclides, Radiological risks, dumping site

INTRODUCTION

Human kinds are exposed to background radiations unknowingly and these exposures to natural occurring radiations are not preventable [1-2-4]. About 80 % exposures to the radiation of the world collectively originated from natural sources and 99% of world population exposed to this radiation dose that occurs as a result of natural sources contribution [3-18]. Other contributions mainly occur as a result of anthropogenic activities such as dumping of waste to unrecommended area, quarry site activities among others. The exposure of human to this natural radioactivity [4] mostly depends on the impact of these anthropogenic activities on types of the soil and geological formation of the area.

Various sources of natural radiations such as earth's crust radionuclide, radionuclide ingestion and irradiation of lung as a result of radon have been characterized as external and internal sources by [1-6-7]. Globally, areas such as china, India, Iran and in Asia are generally found to have high background radiation [12-11]. Furthermore, study have shown that some work have been carried out in some places in Nigeria on background radiation. These areas include – Abeokuta, Alizaga Quarry, Maloney hill quarry in Keffi, Nigeria Coal mine, Okaba and Okpara mines [10-5-8-9]. The present study therefore aims at assessing the impact of radioactivity and radiological activities from a dumpsite in Ota, Ogun State, south west Nigeria on inhabitants residing around the area.

The study area

The area of study is located at eastern part of Ado-Odo/Ota Local Government Area in Ogun State. It lies between latitude $6^o41.349' - 6^o41.485' N$ and longitude $3^o12.007' - 3^o12.991' E$. T he area falls within Dahomey basin southwestern Nigeria and have the following geological formations namely; Alluvium, Coastal Plain Sands, Ilaro formation, Oshoshun formation, Ewekoro Abeokuta formation and Basement Complex. There are two distinct seasons in the state, namely, the rainy season which lasts from March to November and the dry season which lasts for the rest of the year, October/November till March/April. The rainfall distribution varies from about 1000 mm in the western part to about 2000 mm the eastern part (Figure 1).

MATERIALS AND METHODS

Thirteen (13) stations were measured in the study area with each station four (4) times and take the average. In the field, the distance between two stations is about 25 m. The dump site was investigated radiometrically in the field using Super–Spec RS-125 portable radiation detector for the purpose of detecting naturally occurring radionuclides and doses that inhabitant's expose to within the area. The handheld unit spectrometer survey meter has high accuracy and its probable measurement errors were about 5%. The RS-125 Gamma Spectrometer from Radiation Solutions Inc, Canada, is the state-of-the art in portable natural nuclides assaying with small size and yet very high sensitivity and reliability, widely regarded as the leading portable unit in this geophysical field. It offers an integrated design with full weather protection, large detector, ease of use and the highest sensitivity in the market segment. This detector is full assay capability with data in K%, U (ppm), Ra (ppm) and Th (ppm), no radioactive sources required for proper operation. The detector is independent private company (Radiation Solutions Inc, 386 Watline Ave, Mississauga, Ontario, Canada).

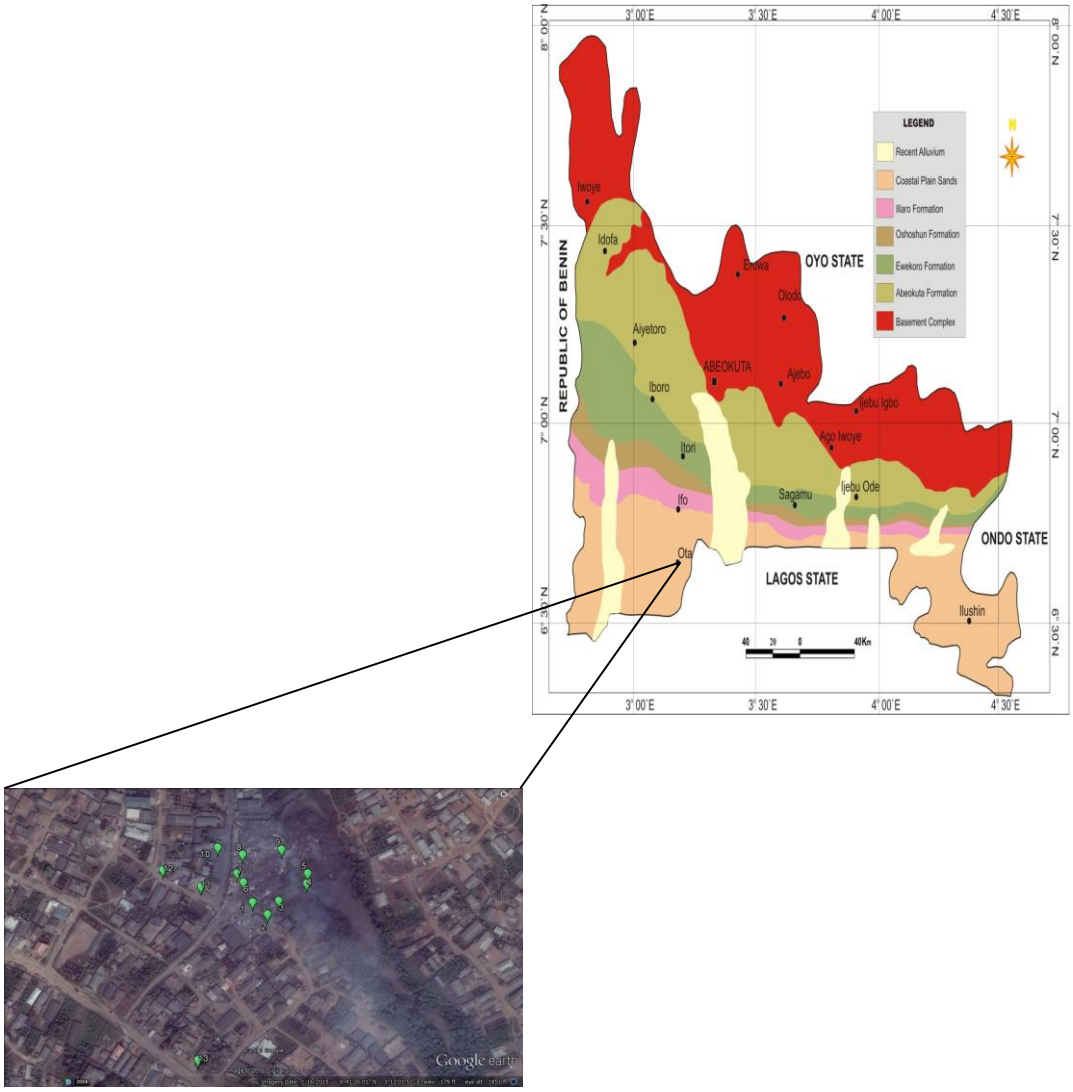


Figure 1: Shows the dumpsite where the data was collected.

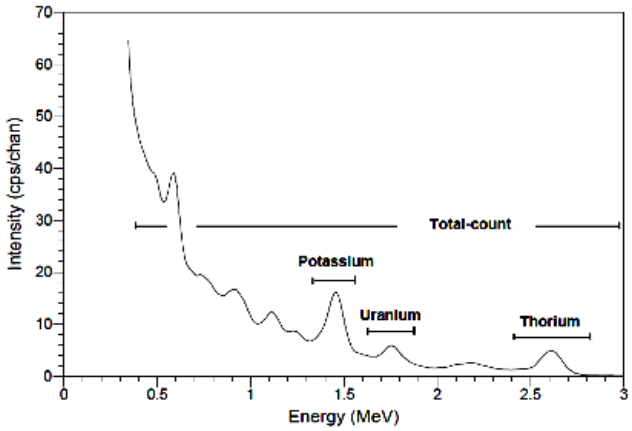
Instrument Sensitivity

The compact RS-125 unit includes a large (103 cm^3) NaI (Sodium Iodine) detector, a 1024 channel spectrometer with a powerful processor. The mechanical design provides ease-of -use, weather protection as well as shock protection. The energy response is 20 keV to 3000 keV. The Sensitivities for Potassium is 55 cpm/%, for Uranium 5 cpm/ppm and for Thorium is 2 cpm/ppm. All functions are handled with one button on the handle. Bluetooth (BT) simplifies data transfer, reporting and if required storage of GPS coordinates with the survey data. The scan function allows for surface mapping. The large (103 cm^3) NaI detector gives the user a high level of system sensitivity. The unit has a front panel with a large 5 digit easy-to-read display, updating at a 1/sec rate for easy source location. The integrated Audio system scans at a 20/sec data rate for fast easy eyes-free searching. In noisy areas users can utilize the Bluetooth linked audio headset for easy-to-hear operation.

Calibration Standard Used for this Study

The detector was calibrated before it was used. The calibration is the procedure that establishes the proportionality between measured counts and ground concentrations of Potassium, Uranium and Thorium. This procedure enables the use of the spectrometer to make qualitative determinations of U, Th and K compositions of surface rocks, environmental wastes and soils. Both airborne and ground instruments are calibrated using international standards developed by the Geological Survey of Canada (GSC) that are traceable to the IAEA [16] in Vienna. This standard of calibration was used for this instrument to ensure consistent and accurate estimation of K, U and Th. Uranium, thorium and potassium in environment, rocks and soils are sources of gamma radiation. Their effects in the air can be expressed in terms of exposure rate or absorbed dose rate by using the conversion factors from radioelement

concentrations in the samples to exposure rate or absorbed dose rate.



Fgure2. The Calibration Curve of the Intensity against Energy

Conversion of Concentration Radionuclides (ppm and &) to Activity Concentration (Bq/kg)

The data obtained in ppm for U and Th, % for K were converted to Bq/kg using the conversion factor by IAEA [13]

Calculation of the external gamma dose rate:

Equation (1) can be used to calculate the external gamma dose rate D_c in air from natural radionuclides [18].

$$D_c = 0.462\ A\ (^{238}U) + 0.604\ A\ (^{232}Th) + 0.0417\ A(^{40}K) \quad (1)$$

where, *Dc* is the absorbed dose rate at 1 m from the ground, A(^{238}U), A(^{232}Th) and A(^{40}K) are the activity concentrations of ^{238}U, ^{232}Th and ^{40}K in Bq kg^{-1} of the sample respectively.

The gamma ray radiation hazards due to the specified radionuclides were assessed by radium equivalent activity and external radiation hazard. Radium equivalent activity Ra_{eq}, and external radiation hazards H_{ex}, respectively, can be calculated according to equations (2) and (3) respectively [18].

$$Ra_{eq} = A_{RA} + 1.43\ A_{Th} + 0.077\ A_K \quad (2)$$

$$H_{ex} = A_{RA}/370 + A_{Th}/259 + A_K/4810 \leq \quad (3)$$

where, $A_{RA} \sim A_U$, A_{Th} and A_K are the average activity concentrations of ^{238}U, ^{232}Th and ^{40}K in Bq kg^{-1}, respectively. For the radiation hazard to be negligible, it is recommended that the Ra_{eq} activity is lower than the maximum value of 370 Bq kg^{-1}, while the H_{ex} must not exceed the limit of unity. The annual effective dose rate (AEDR) in units of μSv y^{-1} was calculated by the following formula

$$AEDR = D_c\ (nGy\ h^{-1}) \times 8760\ h \times 0.2 \times 0.7\ Sv\ Gy^{-1} \times 10^{-3} \quad (4)$$

To estimate the AEDR, the conversion coefficient from absorbed dose rate in air to effective dose (0.7 Sv Gy^{-1}) and outdoor occupancy factor (0.2) proposed by [18] was used.

.

RESULTS AND DISCUSSIONS

From the spectrometer, the data contents in (ppm) for different nuclides such as U, Th and K% for thirteen stations which were converted to Bq/kg are presented in Table 1. The activity concentration of ^{238}U ranged from 2.47 ± 0.3 to 25.01 ± 1.0 Bq/kg with the highest value found in station 11. The activity concentration of ^{232}Th ranged from 12.49 ± 0.8 to 105.97 ± 1.7 Bq/kg with the highest value noted at station 12 whereas the lowest value reported at station 4. The activity level of 40K varies from 15.65 ± 0.8 to 105.97 ± 1.7 Bq/kg with the highest value of 105.9 ± 1.7 Bq/kg was noted at station 7 and 8 respectively. It can be noted that the higher activity levels were increasing toward station increase, that means toward the NE-SW trend of the study area where densely population of the inhabitants reside. Considering the above results for activity concentrations of ^{238}U, ^{232}Th and ^{40}K from the Dup-site, it is clear that the concentration of ^{232}Th is higher than 40K and 238U. The values of ^{238}U, ^{232}Th and ^{40}K are within the acceptable levels of UNSCEAR [18] concentration in (ppm). For the radiological risks, the gamma dose rate (GDR) obtained from the present study rages from 12.65 ± 2.2 to 44.45 ± 6.6 nGh^{-1} with the highest value noted in station 12. The radium equivalent (Req) activity from the present study varies from 27.026 to 162.62 Bq/kg with the highest value of 162.62 Bq/kg found at station12. At the same time, the annual effective dose (AED) found in the area ranges between 0.016 mSvh^{-1} to 0.55 mSvh^{-1}. It can be observed that the same station 12 reported higher with a value of 0.55 mSvh^{-1}. The external hazard index from this study varies from 0.075 to 0.4 with station 12 found with the highest value. From all indications, the inhabitants living at the SW part of the study area where the tilting direction of the Dump-site face appears to be exposed more. Such higher level may be associated with the erosion washing the debris from the site

towards the densely populated region. Station 13 was far lower that the values obtained at station 12 which is 500 m away from the site and may be the safest distance for the inhabitant for further health risk

CONCLUSIONS

In the study area, the chemical and physical alterations play their role in the redistribution of radionuclides in different stations which were subjected to these erosion processes. This distribution of radionuclides reflects its impacts on the environment towards SW part of the study area. Considering the results of the activity concentrations of 238U, 232Th and 40K, they are within the range recommended by [18].

1886 ISSN 1013-5316;CODEN: SINTE 8 Sci.Int.(Lahore),28(2),1883-1887,,2016

Table 1. The Activity concentrations, Gamma dose rate, Radium Equivalent Annual Effective and External Hazard Index from the Study Area after Conversion According to IAEA [15]

stations	U (BqK^{-1})	Th (BqK^{-1})	K (BqK^{-1})	Gamma Dose Rate (nGh^{-1})	R_{eq} (Bq/kg)	AED $mSvh^{-1}$	H_{ex}
1	10.81 ± 0.3	14.52 ± 0.4	31.3 ± 0.2	15.48 ± 0.6	33.972	0.019	0.092
2	7.719 ± 0.8	28.12 ± 1.8	39.13 ± 0.2	23.60 ± 2.1	49.938	0.029	0.138
3	5.25 ± 0.3	14.52 ± 0.7	24.475 ± 0.2	12.65 ± 2.2	27.89	0.016	0.075
4	2.47 ± 0.3	16.65 ± 1.1	39.125 ± 0.2	13.65 ± 0.1	29.286	0.017	0.079
5	11.12 ± 0.7	22.43 ± 2.0	31.30 ± 0.2	20.97 ± 2.7	45.603	0.026	0.124
6	15.13 ± 0.4	16.55 ± 1.3	39.125 ± 0.2	18.98 ± 2.4	41.801	0.023	0.113
7	12.35 ± 0.5	14.31 ± 1.2	46.95 ± 0.2	16.73 ± 4.0	36.431	0.021	0.098
8	5.56 ± 0.4	12.49 ± 0.8	46.95 ± 0.2	13.15 ± 1.6	27.026	0.016	0.073
9	13.59 ± 0.8	17.26 ± 0.8	39.125 ± 0.2	19.43 ± 2.8	41.272	0.024	0.111
10	8.03 ± 0.8	13.70 ± 1.0	15.65 ± 0.2	13.43 ± 2.8	28.828	0.016	0.078
11	25.01 ± 1.0	36.95 ± 1.7	31.30 ± 0.2	36. 85 ± 2.3	80.252	0.045	0.218
12	9.88 ± 1.0	105.97 ± 0.6	15.65 ± 0.2	44.45 ± 6.6	162.616	0.055	0.439
13	14.82 ± 0.5	41.29 ± 1.2	31.3 ± 0.2	30.63 ± 0.6	73.858	0.038	0.199

The gamma dose exposure rate ranged from 12.65 ± 2.2 to 44.45 ± 6.6 nGh^{-1}, the annual absorbed dose rate ranged from 0.24 to 20.50 mSvy-1 and the absorbed dose rate ranged from between 0.016 $mSvh^{-1}$ to 0.55 $mSvh^{-1}$ and the external hazard index of 0.075 to 0.4 are within the permissible average world limit when compared with 2.5 $mSvy^{--1}$ and also the recommended limit of 20 $mSvy^{-1}$[15]. The information gathered from this study will be very useful to determine the radiological impact on inhabitants residing closer to the dump site and for land use development in affected areas. The higher value obtained in station 12 indicates that the inhabitants are advised to relocate or adjust 500 m away from the site especially during rainy season. This work permits us to make the first steps in establishing a database reference of natural radionuclide concentrations in the study area and conclude that the area under study may not be safe for inhabitants residing towards SW due to long term accumulation.

ACKNOWLEDGMENT

We wish to thank Covenant University for all the facilities, equipment and financial support for the present study. Indeed, with their support, they have paved way for further background radiation assessments in other related areas.

REFERENCES

[1] Sadiq A.A and Agba E.H (2011). Background radiation in Akwanga, Nigeria. Facta Univ Ser Work Living Environ Prot 8:7–11.

[2] Ramli A.T, Aliyu A.S, Agba E.H and Saleh M.A (2014): Effective dose from natural background radiation in Keffi and Akwanga towns, Central Nigeria. Int J Radiat Res 12:47–52.

[3] UNSCEAR (1993). Sources, effects, and risks of ionizing radiation. Report to the General Assembly, New York

[4] Garba, N.N, Raml , A.T Saleh, M.A, Sanusi ,M.S and Gabdo H.T (2014). Assessment of terrestrial gamma radiation dose rate (TGRD) of Kelantan State, Malaysia: Relationship between the geological formation and soil type to radiation dose rate. J Radioanal Nucl Chem, 302:201–209.

[5] Farai, I.P and Jibiri, N.N., (2000). Baseline studies of Terrestrial outdoor gamma dose rate levels, in Nigeria. Radiat. Prot. Dosim. 88 (3), 247–254.

[6] War S .A, Nongkynrih P, Khathing D.T and Iongwai P.S (2009). Assessment of indoor radia□on level in environs of the uranium deposit area of West Khasi Hills District, Meghalaya, India. *Journal of Environmental Radioactivity*, ***100:*** *965 - 969.*

[7] Obioha F.I and Okwonkwo P.O (2001). Background gamma radiation in Nigerian Environment. *West Afri Radiol****, 8:*** *16 - 19.*

[8] Sadiq A.A, Liman MS, Agba E.H, Abdullahi E, Lawal Z, Ibrahim U, Gurku M.U(2010). Assessment of exposure to ionizing radiation in selected mining sites of Nasarawa state, Nigeria. *Intergrated Journal of Science and Engineering*,**9:** 46-51.

[9] Mokobia C.E and Balogun F.A (2004). Background gamma terrestrial dose rate in Nigeria functional coal mines. *Radiat Prot Dosim*, ***108:*** *169 - 173.*

[10] Farai I.P and Vicent U.E (2006). Outdoor radia□on level measurement in Abeokuta, Nigeria. Thermo luminescent Dosimetry. *Nig Journ Phys*, **18:** *121 - 126.*

[11] Gholami M, Mirzael S, Jomehzadeh A (2011). Gamma background radia□on measurement in Lorestan Province, *Iran. Iran J Radiat Res*, ***9:*** *89 - 93.*

[12] Ghiassi-nejad M, Mortazavi S.M.J, Cameron J.R, Niroomand-rad A and Karam P.A (2002). Very high background radiation areas of Ramsar, Iran: Preliminary Biological studies. *Heath Physics*, **82:** 87-93.

[13] IAEA, (1990). The Use of Gamma-Ray Data to Define the Natural Radiation Environment. Vienna, Austria, Technical Report Series No.566, IAEA, pp 48.

[14] ICRP, (1991). Recommendations of the International Commission on Radiological Protection. ICRP Publication 60, Ann. ICRP Report 21, pp1-3.

[15] IAEA, (1991). Airborne Gamma-Ray Spectrometer Surveying. Vienna, Austria. Technical Report Series No. 323, IAEA, pp 97.

[16] IAEA, (1996). Internal Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources. Safety Series No. 115.

[17] ICRP, (1997). General principles for radiation protection of workers. ICRP Publication 75, Ann. ICRP 27/1.

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