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Investigation of Radiation Levels in Soil Samples Collected from Selected Locations in Ogun State, Nigeria

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Abstract

Present study measured the terrestrial radiation and evaluated absorbed dose rates from primordial radionuclides ^{238}U, ^{40}K and ^{232}Th in sixty soil samples collected from north, west, east and south of Ewekoro cement factory premises, Owowo village situated adjacent to the factory and Covenant University, Ogun State using the gamma ray spectrometry method. The gamma absorbed rate and annual effective dose equivalent were calculated so as to estimate the hazard index of the primordial radionuclides. Measured concentrations of radionuclides in Ewekoro cement factory soils were as follow: [^{238}U {1.60±1.60 Bqkg^{-1} (east) - 2.56±0.08 Bqkg^{-1} (north)}, ^{232}Th {44.78±1.83 Bqkg^{-1} (east) - 56.62±1.96 Bqkg^{-1} (north)}, ^{40}K {261.54±12.67 Bqkg^{-1} (south) - 342.08±14.17 Bqkg^{-1} (east)}] and Owowo village [^{238}U {1.78±0.09 Bqkg^{-1} (east) - 2.62±0.08 Bqkg^{-1} (north)}, ^{232}Th {50.07±1.93 Bqkg^{-1} (west) - 61.69±1.89 Bqkg^{-1} (north)}, ^{40}K {244.11±13.38 Bqkg^{-1} (north) - 296.40±14.90 Bqkg^{-1} (south)}]. These locations have higher concentration of all radionuclides than that of Covenant University soils, which are as follows: [^{238}U {0.62±0.07 Bqkg^{-1} (south) - 1.07±0.06 Bqkg^{-1} (north)}, ^{232}Th {30.23±1.87 Bqkg^{-1} (south) - 38.87±1.78 Bqkg^{-1} (east)}, ^{40}K {243.35±12.57 Bqkg^{-1} (south) - 301.15±13.55 Bqkg^{-1} (north)}]. The mean absorbed dose and annual equivalent effective dose is 40.88 nGyr^{-1} and 0.05 mSv respectively. The study found that the activity concentrations and radiological hazard index from samples from Ewekoro and the neighbourhood are consistently higher than those from Covenant University however; the values are less than the recommended safe levels.

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Keywords: Primordial radionuclides, Activity concentrations, Soils, Ewekoro cement factory, Covenant University

1. Introduction

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Radionuclides such as ^{40}K, the decay series of ^{232}Th and ^{238}U constitute mainly the natural radioactivity which is found nearly everywhere, in soil, water and rock [Tzortzis and Tsertos, 2004]. Human is exposed to radiation since inception from these primordial radionuclides in two ways, either as direct exposure, or from accumulation of the radionuclides in the body through inhaling or food consumption [Abdul *et al.*, 2010]. In evaluating the health risk of these radionuclides to the human population, estimation of the distribution of radiation dose is very vital so as to serve as the database in monitoring any alteration in environmental radioactivity in soil due to man-made events. Radiation protection and assessment is important because the radionuclides are not equally spread in soil and rock [Avwiri, 2005]. Cement is produced mainly from limestone and some small quantities of other materials such as clay, shale ash and ion oxide [White, 1981]. They contain elements such as gypsum, that has silicate and aluminates that are capable of ionizing [White, 1981]. Limestone which is the main constituent in cement is largely abundant in the earth crust (the residence of primordial radionuclides). Therefore, one of the potential sources of indoor/external exposure is the materials from the earth's crust that are used in the building of where people are dwellings [Ademola and Oguneletu, 2005]. A crucial process in cement production is the quarry process. Research has shown that this process increases the activity concentration of radionuclides in the production environment [Okedeyi *et al.*; Gbadebo, 2011]. However, there are dearths of information on the radioactivity measurement of the effect of Cement manufacturing company in Ewekoro to the human population. Therefore, this work measures the specific activity of ^{40}K, ^{234}Th, and ^{238}U and estimated the radiological hazard associated with them in soil samples obtained in Ewekoro cement plant, Owowo a neigbouring community and Covenant University Ota all in Ogun State.

1.1 Materials and Methods

Soil Samples were taken from Ewekoro cement plant cited in Itori local government located at 6°56'N and 3°13'E Nigeria Owowo village situated adjacent to the cement factory and Covenant university located in Ota 6°41'N and 3°41'E the local government headquarter of Ado-odo Ota Ogun State, Southwestern Nigeria. The locations are within the Eastern Dahomey Basin of Nigeria. Sixty samples were taken from north, south, west and east of each study area. The study area was divided into three zones: Ewekoro cement factory, neighbourhood of the factory site and Covenant University Ota. An area of 3 × 3 m^2 square was demarcated at every sampling point, the top soil layer that is having plant and dead leave was removed before the samples were taken. 2 kg of soil sample are taken from five positions in selected area using hand trowel, which are mixed together to represent the position. The samples were dried until weight remain unchanged and packed 240 g each in cylindrical plastic container and sealed for about 30 days to allow the radionuclides to reach secular equilibrium before radiometric analysis was carried out.

1.2 Gamma Spectrometry Analysis

Each sample was counted for 36,000 seconds so as to achieve minimum counting error in a 7.6 cm x 7.6 cm NaI (Tl) detector coupled to a Canberra Series 10 plus Multichannel Analyzer by a preamplifier base. The detector has a resolution of about 8% at 0.662 MeV of ^{137}Cs which has the capability of identifying the gamma ray energies used for the acquisition. Measurement of ^{40}K was done at photopeak of 1.460 MeV, that of ^{238}U done with from ^{214}Bi at 1.760 MeV photopeak and ^{232}Th done from ^{208}Tl at photopeak 2.614 MeV. The detector has 25% efficiency and calibration was done using an IAEA-375 Reference soil supply by [IAEA, 2003]. The analysis of gamma ray spectrometry used here has been used by other researchers so as to ascertain good quality [Olomo *et al.*; Ajayi and Ajayi, 1999; Tchokossa *et al.*, 2011 and Iqbal *et al.*, 2010]. The mean specific activity was computed using equation (1)

$$A_c = \frac{A_{net}}{M_s . t_c . P_\gamma . \xi} \quad \ldots\ldots\ldots \qquad (1)$$

1.3 Results and Discussion

Activity Concentration

The activities of the primordial radionuclides (^{238}U, ^{232}Th, and ^{40}K) in the obtained samples were presented in Table 1. It was observed that the activity of ^{232}Th in the soil samples is much higher than that of ^{238}U and it ranges from 30.23 Bqkg^{-1} (NU2) to 61.69 Bqkg^{-1} (NN1) having average activity of 46.91±1.87 Bqkg^{-1}. ^{238}U concentration in the soil samples ranges from 0.62 Bqkg^{-1} (NU2) to 2.61 Bqkg^{-1} (NN1) having average activity of 1.67±0.35 Bqkg^{-1} and was found to be less than that of both ^{232}Th and ^{40}K. The activity of ^{40}K in all the samples was found to be higher when compared to that of ^{232}Th and ^{238}U in all sampling locations studied, it ranges from 243.35 Bqkg^{-1} (NU3) to 342.08 Bqkg^{-1} (NE3) having average activity of 280.52±14.04 Bqkg^{-1}. Correlations of three primordial radionuclides in the samples was plotted in order to compare their activity concentrations. Figure 1(I-III) represent the correlations of the concentration of ^{238}U and ^{232}Th, ^{232}Th and ^{40}K and ^{238}U and ^{40}K respectively. A trend line was drawn between the points using regression analysis technique. The regression results were positive and linear for the three plots. The correlation coefficient of ^{238}U and ^{232}Th was also observed to be high with a value of 0.96, whereas correlation between ^{238}U and ^{40}K and ^{232}Th and ^{40}K was very low. This was not surprising, since ^{238}U and ^{232}Th come from natural decay series while ^{40}K, though a primordial radionuclide, which does not undergo any decay. However, a positive correlation obtained may be attributed to the retaining potential of the soil of these radionuclides under different atmospheric situations. It was also observed from Table 1 that the mean value of ^{40}K was the highest and that of ^{238}U was the lowest in all the study area. The spatial distribution of the radionuclides across the three locations revealed that the concentration of ^{40}K and ^{234}Th was highest at the neighbouring settlement while Covenant University has the lowest concentration of ^{238}U and ^{234}Th. The low concentration obtained in Covenant University can be attributed to the fact that the site upon which the University is built about ten years ago was a virgin land. This can be corroborated with the presence of a number of local indigenous trees found within the premises. The result also revealed that highest concentrations of the three radionuclides were obtained in the samples from Ewekoro cement and its neighbourhoods by factor of 23% of ^{238}U, 49% of ^{232}Th and 71% of ^{40}K above that of Covenant University. The results presented here are within the limit of the average concentration of these radionuclides reported for soil [UNSCEAR, 2000].

1.4 Estimation of Absorbed Dose Rates and Annual Effective Dose Equivalent

The absorbed dose and the annual effective dose equivalent of the primordial radionuclide from the collected samples were calculated using equations given by [UNSCEAR, 2000]. The estimated gamma absorbed doses in air ranges from 28.77 nGy.h^{-1} to 48.38 nGy.h^{-1} having an average value of 40.88 nGy.h^{-1} for the study area, which is less than the recommended world average value of 60 nGyh-^{1}. The differences arising from these may be due to the influence of the cement manufacturing and geological settings of the area, this vary from one place to another and from one locality to another even within the same region. The knowledge of absorbed dose rate is important for estimating radiation havoc done to the population as a whole, whereas some members of the population may incur higher doses due to high concentration of radionuclides from their own environment. Change in the soil activity with location depends on soil physical and chemical properties which are common phenomenon in any assessments of radiation in the environment. ^{232}Th has the largest contribution to the absorbed doses in the study area. The calculated values of annual effective dose range between 0.035 and 0.06 mSv, having an average value of 0.05 mSv, which is less than the recommended world average of 0.48 mSv [UNSCEAR, 2000].

2. Conclusion

The radioactivity concentrations of ^{238}U, ^{40}K and ^{232}Th in soil samples taken from Ogun State as investigated using gamma ray spectrometer showed that there are low level activities in the studied locations. The average activity concentrations of ^{238}U, ^{40}K and ^{232}Th, is 1.67±0.35 Bqkg^{-1}, 280.52±1.87 Bqkg^{-1} and 46.91±1.87 Bqkg^{-1} respectively. The results obtained in the present study fall within the recommended limit proposed by UNSCEAR and other relevant organizations worldwide. The average dose rates and the annual dose equivalent calculated is 40.88 nGyh-^{1} and 0.05 mSv, which are less than the recommended worldwide average value. Though, the result showed that the radiation levels in the cement factory and adjacent village are higher than those obtained in Covenant University location, all the estimated values were within the recommended safe limit. Thus, this study establishes a baseline data of primordial radionuclides for these areas, most especially for the cement factory. In conclusion, in accordance to our finding the soil of the study areas do not expose the people in the area to any health challenge.

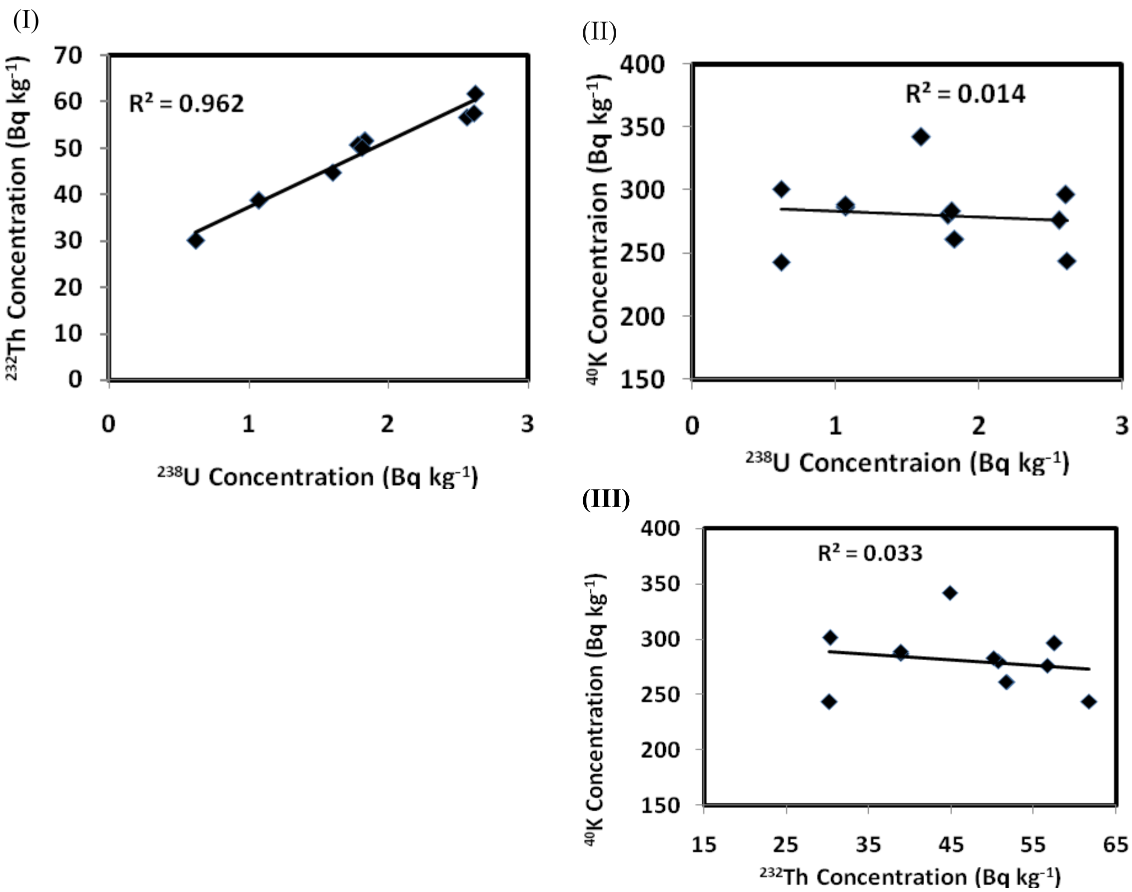

Fig.1: **(I)** Correlation of ^{238}U and ^{232}Th activities; **(II)** correlation of ^{232}Th and ^{40}K activities; **(III)** correlation of ^{238}U and ^{40}K activities;

Table 1 Measured Radioactivity Concentrations in the samples (Bq kg^{-1})

Code	Location	Samples Size	^{238}U	^{40}K	^{232}Th
NE1	Ewekoro North	5	2.56±0.08	276.21±13.25	56.62±1.96
NE2	Ewekoro South	5	1.83±0.08	261.54±12.67	51.70±1.79
NE3	Ewekoro East	5	1.60±1.60	342.08±14.17	44.78±1.83
NE4	Ewekoro West	5	1.83±1.83	261.54±13.38	51.57±1.89
NN1	Owowo North	5	2.62±0.08	244.11±13.38	61.69±1.89
NN2	Owowo South	5	2.61±0.10	296.40±14.90	57.50±2.02
NN3	Owowo East	5	1.78±0.09	280.42±14.62	50.73±1.85
NN4	Owowo West	5	1.81±0.08	283.17±15.43	50.07±1.93
NU1	Cov. Univ. North	5	0.62±0.07	301.1513.55	30.28±1.81
NU2	Cov. Univ. South	5	0.62±0.06	243.35±12.57	30.23±1.87
NU3	Cov. Univ. East	5	1.07±0.06	287.17±15.43	38.87±1.78
NU4	Cov. Univ. West	5	1.07±0.07	289.10±15.19	38.84±1.80
Range			0.62-2.61	243.35-342.08	30.23-61.69
Mean			1.67±0.35	280.52±14.04	46.91±1.87

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References

[1] Tzortzis M and Tsertos H 2004. Natural radioelement concentration in the Troodos Ophiolite Complex of Cyprus Seminar submitted to Department of Physics, University of Cyprus 1-21
[2] Abdul Jabbar, Waheed Arshed, Arshad Saleem Bhatti, Syed Salman Ahmad, Perveen Akhter, Saeed-Ur-Rehman, Muhammad Iftikhar Anjum. *2010.* Measurement of soil radioactivity levels and radiation hazard assessment in southern Rechna interfluvial region, Pakistan. *Environ Monit Assess 169:429–438*.
[3] Avwiri, G.O. 2005 .Determination of Radionuclide Levels in Soil and Water around Cement Companies

in Port Harcourt; *J. Appl. Sci. Environ. Mgt. Vol. 9 (3) 27 – 29*.
[4] White, G.R. 1981. Concrete Technology, 3rd Ed. John . Delmar Publishers, USA, 18 – 19.
[5] Ademola J.A., Oguneletu P.O., Radionuclide content of concrete building blocks and radiation dose rates in some dwellings in Ibadan, Nigeria. *Journal of Environmental Radioactivity 81 (2005) 107-113.*
[6] Okedeyi, S.A., Gbadebo A.M., Arowolo T.A. and Tchokossa P., 2012. Measurement of Gamma-emitting Radionuclides in Rocks and Soils of Saunder Quarry Site, Abeokuta, Ogun State, Nigeria. *Journal of Applied Sciences, 12: 2178-2181.*
[7] Gbadebo, A.M., 2011. Natural radionuclides distribution in the Granitic rocks and soils of abandoned quarry sites, Abeokuta, Southwestern Nigeria. Asian J. Applied Sci., 4: 176-185.
[8] Journal of International Atomic Energy Agency Vienna (IAEA) 2003; Tech Report 419: 30.
[9] Olomo, J.B., Akinloye M.K. and Balogun F.A., 1994. Distribution of γ-emitting natural radionuclides in soils and water around nuclear research establishments, Ile-Ife, Nigeria. *Nucl. Instr. Meth. Phys. Res., 353: 553-557.*
[10] Ajayi, S.O. and Ajayi I.R., 1999. A survey of environmental gamma radiation levels of some areas of Ekiti and Ondo States, Southwestern Nigeria. *Nig. J. Phys., 11: 17-21.*
[11] Tchokossa, P., J.B. Olomo and F.A. Balogun, 2011. Assessment of radionuclide concentrations and absorbed dose from consumption of community water supplies in oil and gas producing areas in Delta State, Nigeria. World J. Nuclear Sci. Technol., 1: 77-86.
[12] Iqbal, M., M. Tufail and Mirza M., 2000. Measurement of natural radioactivity in marble found in Pakistan using a NaI(Tl) gamma-ray spectrometer. *J. Environ. Radioact., 51: 255-265.*
Environmental, Health, and Safety Guidelines 2007. Cement and Lime Manufacturing Report.
[13] United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 2000 report, Sources and effects of ionizing radiation Volume 1