International Journal of Basic Science and Technology, Vol. 4 No 1 (2018) p.12-16

# Determination of Annual Gonnodal Dose Equivalent Arising from Natural Radioactivity in Soil of Ika North East Local Government Area of Delta State, Nigeria

**Eseka, K., Molua, O.C. and Upkene, O.A.**
**College of Education, Agbor, Delta State Nigeria**

Received:11th Dec.,2017
Accepted: 6th Mar., 2018
Available online
25th April, 2018

**Keywords**
Radiometric, Soil Recommendation Standard, Gonnodal Dose, Health

**Abstract**: The radiometric survey of soil samples collected from some communities in Ika North-East local Government area of Delta State, Nigeria were investigated using gamma-ray [NaI(TI)] Spectroscopy. The average activity concentration of $^{40}K$, $^{238}U$ and $^{232}Th$ in soil samples from the selected communities were 512.43 ± 1.91 $Bqkg^{-1}$, 37.49±2.44 $Bqkg^{-1}$ and 29.46 ± 2.42 $Bqkg^{-1}$ respectively. By comparing with recommendation standard, it was observed that the obtained average results of $^{40}K$ and $^{238}U$ exceeded the standard value limit of 400 $Bqkg^{-1}$ and 30 $Bqkg^{-1}$respectively. The calculated radiological hazard values were lower than the world average standard except for the annual gonnodal dose equivalent that exceeded the world average value by 33.3%. Therefore in conclusion, exposure to the soils in these communities will pose little or no health problem to the inhabitants in these communities

Corresponding author: moluaogom@hotmail.com

## Introduction

Soil gives a direct source of radioactivity in food chain as a result of its uptake by agricultural produce (Hasan *et al*., 2014). These various radionuclides detect their way into meat, aquatic life and even milk. With these one can say that soil is a major source of radionuclides to living organism (Jwanbot *et al*., 2014)

The distribution of radionuclides on earth, their level of concentrations and movements can seriously be affected by the activities of population (Farai *et al*., 2000). This can cause effects such as harmful consequences on environment and health problems to the populace, either into the body through different metabolic pathways. The natural radioactivity in the environment is the main source of radiation exposure for human being that may come from available natural sources (Hasan *et al*., 2014). Natural radionuclide in soil contributes a significant amount of the population through inhalation and ingestion. The main contributor of radionuclides includes $40^{K}$ and $232^{Th}$ and these naturally radionuclides are not uniformly distributed in soils and vary from environment to environment (Jibiri, 2009)

## Materials and Methods

A total of twenty five representative soil samples were collected for the work. The samples were collected with the aid of a hand trowel at a dept range of 0-15cm. At the point of sampling, sampled soil were sealed in a black bag and labeled accordingly to avoid cross contamination of samples. The collected soil samples were then air dried at room temperature and sieved through a fine mesh of about 0.5mm and analysed using NaI (TI) gamma ray spectrometry (Almayahi, 2015). The samples were then packed and sealed in a special container for about 30 days to allow the radionuclides reach secular equilibrium before spectrometric analysis (Almayahi, 2015).

### 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 (Manigandan and Natrijan, 2014).

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 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 was supply by International Atomic Energy Agency (Oregioni and Aston, 1984). The analysis of gamma ray spectrometry used has also been employed by Iqbal *et al*. (2012).The activity concentration of the premodial redionuclides present in the collected soils samples using the equation

$Cs=NEy \quad \varepsilon E\gamma \times Mv \times tc \times P\gamma$ (Bq/kg)

Where Cs= Sample concentration, NEy= net peak area of a peak at energy, εEy= Efficiency of the detector for a γ-energy of interest, Mv=Sample volume, tc= total counting time, Pγ = Emission probability of radionuclide of interest (Avwiri *et al*., 2015)

Absorbed dose rate (D) in ngy $yr^{-1;}$

$D = 0.048C_k + 0.446C_u + 0.660C_{Th}$

where $C_k$, $C_u$ and $C_{Th}$ are the activity concentration in Bq/Kg for K, U and Th respectively (UNSCEAR 2000)

ii. Annual effective dose $h_e$

$H_E$ = D X T X F
Where D is the calculated dose rate, $T_{out}$ is outdoor occupancy time = 0.2 x 24h x 365.25, $T_{in}$ is indoor occupancy time = 0.8 x 24h x 365.25, F is the
iii. Radium equivalent activity index ($Ra_{eq}$); Allows a single index or number to describe the gamma output from different mixtures of U, Th and K from different communities; $Ra_{eq} = C_u + 1.43C_{Th} + 0.077C_K$
where $C_k$, $C_u$ and $C_{Th}$ are the activity concentration in Bq/Kg for U, Th and k respectively (UNSCEAR 2000)
iv. Annual gonnodal equivlent dose (aged) in mSv/yr
$AGED = 3.09C_u + 4.18C_{Th} + 0.314C_k$
conversion factor = 0.7 x $10^{-6}$ $SvGyh^{-1}$(conversion coefficient from absorbed dose in air to effective dose received) (UNSCEAR, 2000)

Where $C_u$, $C_{Th}$ and $C_K$ are the activity concentrations of U, Th and K in Bq/K ( Avwiri *et al*., 2012 )
v. Excess lifetime cancer risk (elcr) in Sv/yr
ELCR = AEDE X DL X RF
Where AEDE = D X 8766 X 0.2 X 0.7 X $10^{-6}$, DL = 70, RF = 0.05
DL is average duration of life (estimated to be 70years)
RF is the risk factor.

Table 1: Specific activity concentration of $^{40}K$, $^{238}U$ and $^{232}Th$ (Bq/kg) results in soil samples

| S/N | Communities | Specific Activity Concentrations In Bq/Kg | | |
|---|---|---|---|---|
| | | $^{40}K$ | $^{238}U$ | $^{232}Th$ |
| 1 | UTE-ERUMU | 493.67±3.63 | 39.15±1.42 | 27.35± 3.21 |
| 2 | UDUMU- ESAH | 498.53±2.17 | 35.10±3.09 | 32.10± 3.43 |
| 3 | OWA- ALERO | 518.71±3.51 | 38.13±2.40 | 30.91± 2.98 |
| 4 | UMUNEDE | 531.30±3.22 | 36.93±1.60 | 29.21± 1.10 |
| 5 | OWA-ALIZOMOR | 521.43±1.91 | 38.15±3.70 | 27.74± 1.40 |
| | AVERAGE | 512.73±2.89 | 37.49± 2.44 | 29.46 ± 2.42 |
| | STANDARD | 400 | 35 | 30 |

Table 2 : Absorbed dose rate D, outdoor/indoor annual effective dose ( E) and Radium equivalent activity $Ra_{eq}$(Bq/Kg)

| S/N | Communities | Absorbed Dose | Outdoor Annual Effective Dose | Indoor annual effective Dose | Radium Equivalent Activity |
|---|---|---|---|---|---|
| 1 | UTE-ERUMU | 59.21 | 0.073 | 0.291 | 104.51 |
| 2 | UDUMU- ESAH | 60.77 | 0.075 | 0.298 | 105.59 |
| 3 | OWA- ALERO | 62.30 | 0.077 | 0.306 | 108.98 |
| 4 | UMUNEDE | 61.25 | 0.075 | 0.301 | 107.05 |
| 5 | OWA-ALIZOMOR | 60.31 | 0.074 | 0.296 | 107.10 |
| | AVERAGE | 60.77 | 0.075 | 0.298 | 106.67 |
| | STANDARD | 60.00 | 1.000 | 1.000 | 370.000 |
| | (UNSCEAR, 2000) | | | | |

Table 3: Annual Gonnadal equivalent dose (AGED), Excess lifetime Cancer risk (ELCR)

| S/N | Communities | Annual Gonnodal equivalent dose (AGED) in mSv/yr | Excess lifetime cancer risk (ELCR) x $10^{-3}$ Outdoor in Sv/yr |
|---|---|---|---|
| 1 | UTE-ERUMU | 390.29 | 0.254 |
| 2 | UDUMU- ESAH | 399.18 | 0.261 |
| 3 | OWA- ALERO | 409.89 | 0.268 |
| 4 | UMUNEDE | 403.03 | 0.263 |
| 5 | OWA-ALIZOMOR | 397.56 | 0.260 |
| | AVERAGE | 399.99 | 0.261 |
| | STANDARD (UNSCEAR, 2000) | 300.000 | 0.29 x$10^{-3}$ |

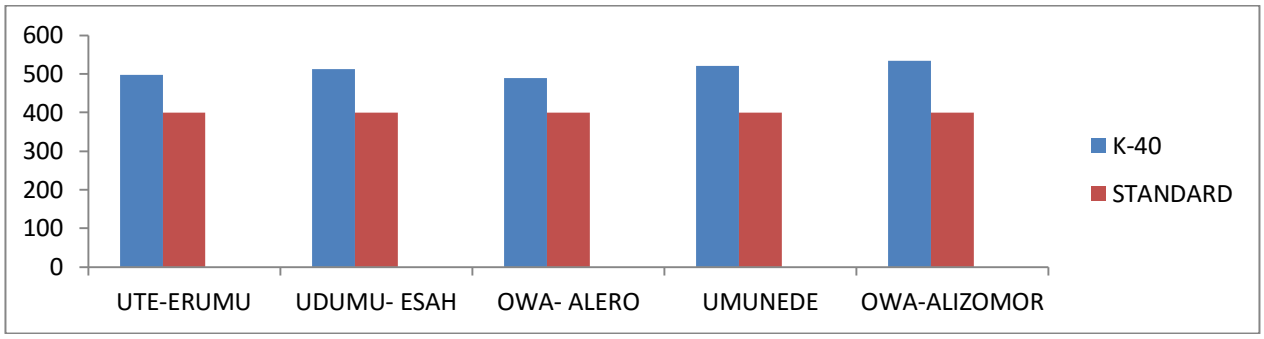


Fig. 1 Comparison of activity concentration of K-40 with UNSCEAR STANDARD

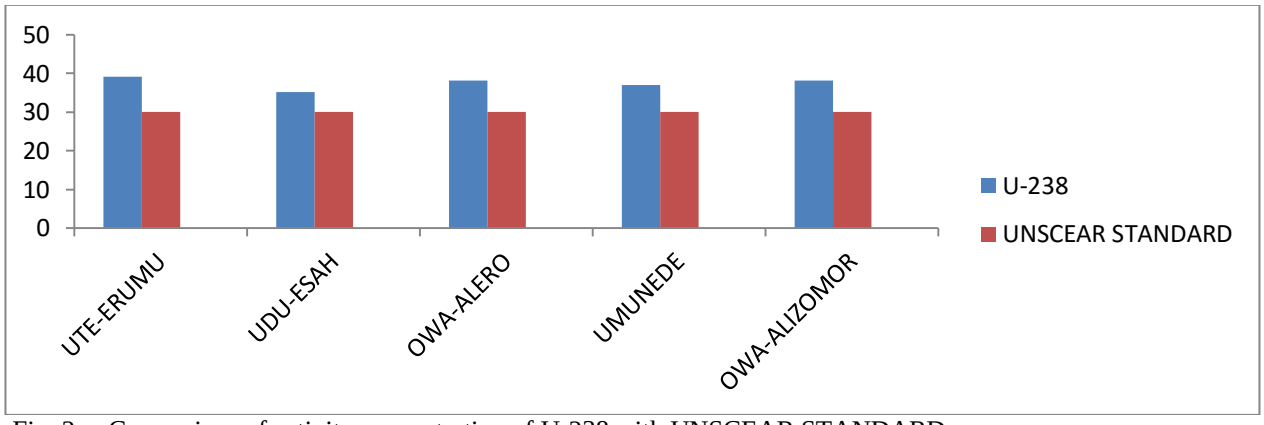


Fig. 2 Comparison of activity concentration of U-238 with UNSCEAR STANDARD

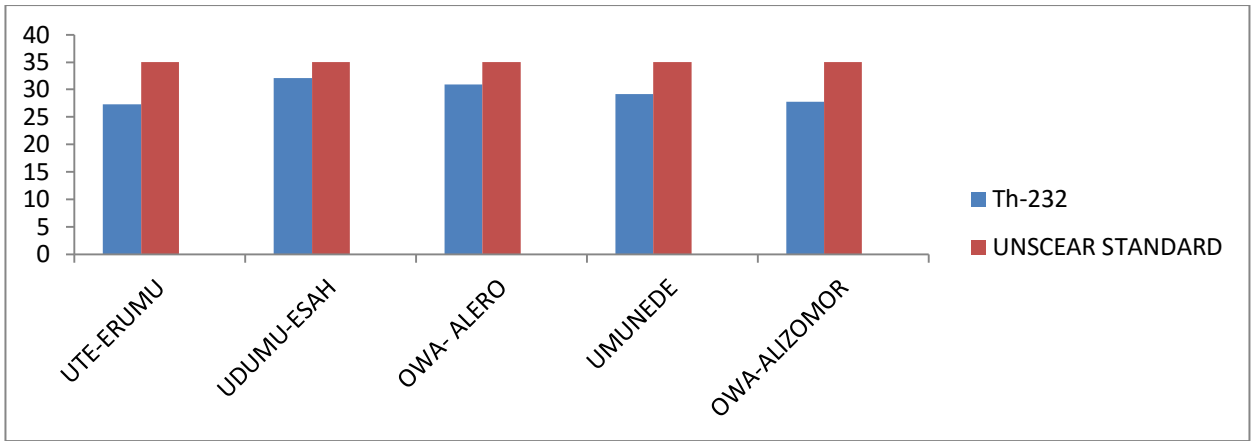


Fig. 3 Comparison of activity concentration of Th-232 with UNSCEAR STANDARD

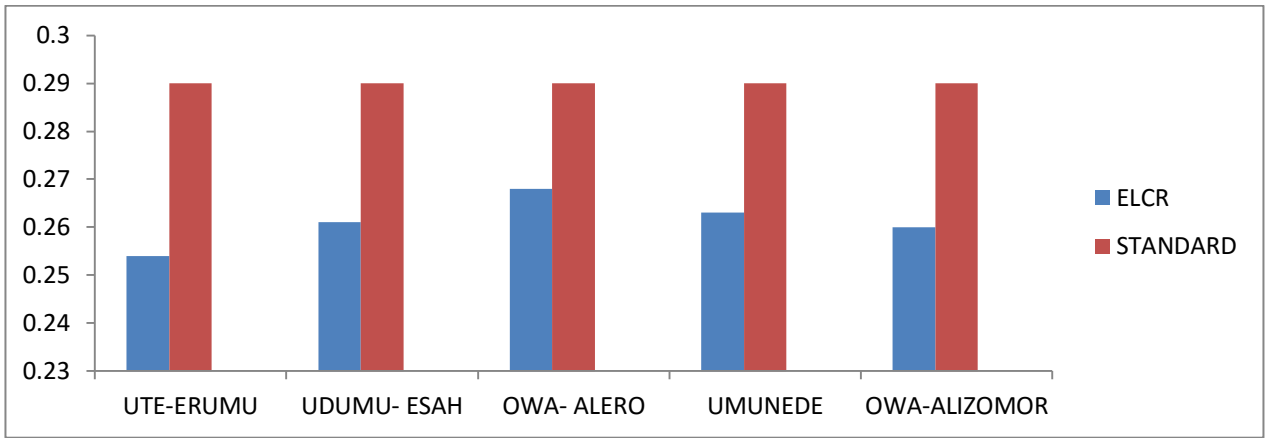


Fig .4: Comparison of ELCR with UNSCEAR STANDARD.

**Discussion**

The result showed that there are low level of activity concentration in the studied locations except for $^{40}K$ and $^{238U}$ which are a little above the world recommended standard. The average activity concentrations of $^{40}K$, $^{238}U$ and $^{232}Th$ are 512.43±1.91 Bq/Kg, 37.49±2.44 Bq/Kg and 29.46±2.42 Bq/Kg. Despite the relatively high activity levels of K and U, one can conclude that exposure to the soil will may not pose much health problem to the people in the area.

The average annual gonnodal equivalent dose (AGEDE) was found to exceed the world standard value by 33.3% as recommended by UNSCEAR (2000). This value poses a relatively high level of threat to sensitive organs like the gonad, thyroid (Jwanbot *et al*., 2012). Average excess lifetime cancer risk from this study is found to be lower than the world average standard of $0.29 \times 10^{-3}$ (Jibiri *et al*.,2007).This indicates that the chances of developing cancer by the people of the area is insignificant.

Beside, this study has shown that the indoor/outdoor annual effective dose together with its radium equivalent dose is all lower than the world standard value of unity (Ramasamy *et al*., 2009). This indicates that the values will not lead to radiation diseases such as skin cancer, lungs cancer, cataracts.

The mean absorbed dose obtained in the study (60.77.00 nGy $h^{-1}$) is very much comparable to the world standard (55 nGy $h^{-1}$).The calculated radiological health indices including the excess life time cancer risk are within the acceptable limit.

In conclusion, the soil of Ika North-East does not expose the people to much health problem and as such the soil is considered safe radiologically

**References**

Almayahi., B.A. (2015). NAI(TI) Spectrometry to Natural Radioactivity Measurement of soil samples In Najaf City*: Iranian journal of Energy And Environment, 6(3):207-211*

Awiri.,G.O., Esi. and Ononugbo, C. (2015). Radiometric survey of soil Samples from coastal area of Delta State, Nigeria. *Global Journal of physics*, 2015:3(1).

Farai, I.P and Jibiri, N.N. (2000). Baseline Studies of Terrestrial Outdoor gamma Doserate levels in Nigeria.*Radiation Protection Dosimeter*. 88(3):247-254

Hasan, M.M., Ali.,M.I.,Paul,D.,Haydar,M.A. and Islam,M.A(2014).Natural Radioactivity and Assessment Of associated radiation hazards in soil and water Supply collected from in and around of the Barapukuria 2x125 Mw coal fired Thermal power plant Dinajpur, *Bangladesh. Journal of Nuclear particle physics*, 4(1):17-24

Iqbal, J., Saleem, M., Shah, M.H. (2012). Study of seasonal variations and risk assessment of selected metals in sediments from Mangla Lake, *Pakistan. J Geochem Explor*. 2012;125:144–52. doi: 10.1016/j.gexplo.2012.12.006.

Jibiri, N.N (2009).Radiological hazard indices due to activity concentrations of NaturalRadionuclides In farm soil from two high Background areas in Nigeria. *International Journal of Low Radiation*. 6(2):74-95

Jibiri, N.N., Farai, I.P and Alausa, S.K (2007). Estimation of Annual Effective Dose due to Natural Radioactive Elements in Ingestions of foodstuffs in tin Mining area of Jos Plateau, Nigeria. *Journal of Environmental Radioactivity*,94:31-40

Jwanbot, D.I., Izam, M.M. and Nyam,G.G. (2012). .Radioactivity in some Food Crops from high Backg round radiation area of Jos-Plateau, Nigeria. *Journal Of natural science research*,3(2): 15-23

Jwanbot, D.I., Izam, M.M and Nyam,G.G.,John,H.N (2013). Radiomrtric Analysis of some soils and Foods crops in Barkin Ladi lGA, Plateau State, Nigeria. *Journal of Environmental and Earth Science*,3(3) 2013.

Manigandan,P.K., and Natrijan, K.K (2014). Activity concentrations of Natural Radionuclisdes in soils of rainforest site in Western Ghats. *International Journal of Students research in Technology and Management* 2(03);103-108

Oregioni, B. Aston, S.R.(1984). Determination of selected trace metals in marine sediments by flame /flameless atomic absorption spectrophotometer. IAEA Monaco Laboratory Internal Report. Now cited in reference method in pollution studies UNEP, No.38.

Ramasamy, V., Suresh, G., Meenakshisundaram, V. and Gajendran, V. (2009). Evaluation of Natural Radionuclide content in River sediments and Excess LifetimeCcancer Risk due to Gamma Radioactivity . *Res. J. of Environmental and Earth Sci.* 1(1): 6-10.

UNSCEAR (2000). United Nations Scientific Committee on Effect of Atomic Radiation. Report to The general assembly Annex B: Exposure from natural radiation source pp102.