

Natural Radioactivity of Soil Samples Collected from Oil Producing Areas in Akwa Ibom State, Nigeria

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Abstract

The study is aimed as assessing the radionuclide concentration of soil samples collected from oil producing areas in Akwa Ibom State, Nigeria. Seven soil samples were collected from a particular location in each of the seven oil producing areas in the state. Before measurement, samples were dried in an oven at a temperature of about 75 degree Celsius for 24 hours. Each sample was packed and sealed in an airtight PVC container and kept for 28 days to allow radionuclide present in the sample to attain a secular radioactive. The analysis was done at the National Institute of Radiation Protection and Research, University of Ibadan, Ibadan, Nigeria. The method employed for the measurement of the activity concentration in the samples was the gamma ray spectroscopy. The detector used for the radioactivity measurements was a lead-shielded 76 x 76 mm NaI (TI) detector crystal. For ⁴⁰K, the activity concentration ranged from BDL (below detection limit) to $535.6 \pm 34.03 \text{ Bq.kg}^{-1}$ with a mean of $202.3 \pm 12.8 \text{ Bq.kg}^{-1}$ for ²³⁸U, it ranged from BDL to $244.6 \pm 39.84 \text{ Bq.kg}^{-1}$ with a mean of $120.1 \pm 9.53 \text{ Bq.kg}^{-1}$. For ²³²Th, the activity concentration ranged from BDL to $50.6 \pm 3.66 \text{ Bq.kg}^{-1}$ with a mean of $26.6 \pm 1.55 \text{ Bq.kg}^{-1}$. Eastern Obolo has the highest activity concentration for ⁴⁰K with a value of $535.6 \pm 34.03 \text{ Bq.kg}^{-1}$, Mkpato Enin and Esit Eket has the highest activity concentration for ²³⁸U and ²³²Th respectively with a value of $244.6 \pm 39.84 \text{ Bq.kg}^{-1}$ and $65.2 \pm 4.72 \text{ Bq.kg}^{-1}$, respectively. Eastern Obolo has the highest distribution of ⁴⁰K in the soil samples while Uyo has the least. Eastern Obolo has the highest percentage distribution of the combined radionuclide in the soil samples with a percentage of 29% while Uyo has the lowest of 5%.

Keywords: Soil, Radionuclides Concentration, Radiation, Akwa Ibom State

1. Introduction

The radionuclides present in the environment transfer to plants through uptake from soil through roots, and direct absorption through aerial parts of the plants (Jibiri *et al.*, 2007). Presence of radioactivity in plant organs has been reviewed by various workers. Direct fallout from the atmosphere on the vegetation is the primary source of radiation contamination. Fission product is strongly absorbed and maintained by soil particles, similar to natural radionuclides, which are

widely distributed at different soil depths (Ghazwa *et al.*, 2016). There are two major pathways for human exposure to soil contamination; (i) soil - plant - human (food chain pathway) and (ii) soil - human (incidental soil ingestion) pathway. Migration and accumulation of radionuclides in the soil-plant system is complex (Chen *et al.*, 2005). High levels of radionuclides in plants are generally found in soils that have high background levels, such as near ore deposits or on contaminated soils and mill tailings. Doses as low as 5Gy can result in morphological changes, reduction of stem growth and root biomass, as well as increased leaf density. This, in turn, may affect the uptake of nutrient (Wohlers and Wood, 2015). Uranium, radium, thorium, potassium and their decay products are among the most important radionuclides and they can be easily transferred from soil to plants through roots. Phosphate rocks which are starting material for production of fertilizers contain high levels of uranium, thorium and other heavy metals. Natural radioactivity in the environment, originating from the naturally occurring radionuclides of ^{232}Th , ^{238}U , and ^{40}K radioactive series, largely contributes to the natural irradiation of man and other living organisms Al-Haydari *et al.*, 2012). This can occur externally or internally. A series of successive radioactive decays occur from parent radionuclides whose offspring are also unstable and is subject to decay in order to become stable. Ionizing radiations such as alpha(α), beta(β) and gamma(γ) are products of decay of these naturally occurring radionuclides. The continuous exposure of human beings to ionizing radiation from natural sources is thus an unavoidable feature of life on earth. This exposure to ionizing radiation also arises from other naturally occurring sources such as radiation from high-energy cosmic ray particles incident on the earth's atmosphere (UNSCEAR, 2000). There are also sources with artificial origin such as medical diagnostic and therapeutic procedures, radioactive material resulting from nuclear weapons testing, energy generation by means of nuclear power, unplanned events such as the nuclear power plant accidents at Chernobyl in 1986 and that following the great East-Japan earthquake and Tsunami of March 2011 (UNSCEAR, 2000). Man-made sources also include routine emissions to the atmosphere from reprocessing plants, nuclear power stations and waste disposal sites (Baldock *et al.*, 2010)

2. Methodology

2.1 Soil Samples Collection and Preparation

The soils from different locations were collected from an auger hole at a depth of about 7.5 cm from the ground so as to get the natural soil. One soil sample each was collected from the locations in the study areas. Therefore, bringing the total number of soil samples collected to be eight. After the soil samples were collected, they were then crushed into fine powder with the use of mortar and Pestle. Fine quality of the soil samples was obtained with the use of a sieve of about 145 micron-mesh size. Seven soil samples were collected from a particular location in each of the seven oil producing areas in the state. Before measurement, samples were dried in an oven at a temperature of about 75 degree Celsius for 24 hours. Each sample was packed and sealed in an airtight PVC container and kept for 28 days to allow radionuclide present in the sample to attain a secular radioactive (UNSCEAR, 2000). The mass of each soil sample was 250 g.



Figure 3.5: Prepared soil samples from the study areas.
Source: The researcher (2026)

2.2 Measurement of Activity Concentration of the Soil samples

The method employed for the measurement of the activity concentration in the samples was the gamma ray spectroscopy. The detector used for the radioactivity measurements was a lead-shielded 76 x 76 mm NaI (TI) detector crystal of model 802 series, Canberra Inc. coupled to a Canberra series multichannel Analyzer (MCA) through a preamplifier with a model of 1104. It has a resolution full width at half maximum (FWHM) of about 8% at energy of 0.662 Mev. The choice of NaI (TI) detector used to detect the radionuclides is based on the fact that it has a modest resolution. The samples collected were placed in a symmetric pattern on top of the detector and measured for a period of about 10 hours. The net area below the corresponding peaks in the energy spectrum was obtained by subtracting counts which occurs as a result of Compton scattering of higher peaks. For this study, the activity concentrations in the samples was obtained using the formulas as shown in Equations 1 and 2 (UNSCEAR, 2000). Figure 7 shows the lead-shielded 76 x 76 mm NaI (TI) detector crystal (Model No.802 series, Canberra Inc. coupled to a Canberra series multichannel Analyzer (MCA) (Model N0.1104) through a preamplifier.

$$C(Bq.kg^{-1}) = KC_n \quad \text{Equation 1}$$

$$\text{Where } K = \frac{1}{\epsilon P_\gamma m_s} \quad \text{Equation 2}$$

C is the activity concentration of the radionuclides in the samples in $Bq.kg^{-1}$, C_n is the count rate under the corresponding peak, ϵ is the detector efficiency at the specific γ -ray energy, P_γ is the absolute transition probability of the specific γ -ray energy, and m_s the mass of the sample in kg (UNSCEAR, 2000).



Figure 1: A lead-shielded 76 x 76 mm NaI (TI) detector crystal (Model No.802 series, Canberra Inc. coupled to a Canberra series multichannel Analyzer (MCA) (Model N0.1104) through a preamplifier. Source: NIRPR, University of Ibadan, Ibadan, Nigeria (2025).

3. Results

3.1 Activity Concentration in Soil Samples

The activity concentration of ^{40}K , ^{238}U and ^{232}Th for the soil samples obtained are presented in Table 1. Figure 1 shows the distribution of the activity concentrations for ^{40}K , ^{238}U and ^{232}Th in Bq.kg^{-1} for the soil samples. Figure 2 shows the percentage distribution of the combined radionuclides (^{40}K , ^{238}U and ^{232}Th) concentration for soil samples obtained from the study areas.

Table 1: Activity concentration of ^{40}K , ^{238}U and ^{232}Th in Bq.kg^{-1} for soil samples from the study areas.

LGA	SAMPLE CODES	^{40}K	^{238}U	^{232}Th
Eastern Obolo	S1	535.6±34.03	243.7±39.70	25.9±1.88
Eket	S2	266.3±16.92	11.0±1.79	BDL
Esit Eket	S3	257.7±16.37	167.0±27.20	65.2±4.72
Ibeno	S4	181.0±11.50	236.6±38.53	7.4±0.54
Ikot Abasi	S5	155.2±9.86	56.2±9.15	40.6±0.00
Mkpat Enin	S6	BDL	244.6±39.84	13.5±0.98
Uruan	S7	216.2±13.74	BDL	50.6±3.66
Uyo	S8	5.6±0.36	BDL	8.7±0.63
	Mean	202.3±12.85	120.1±9.53	26.6±1.55

Source: The researcher (2026)

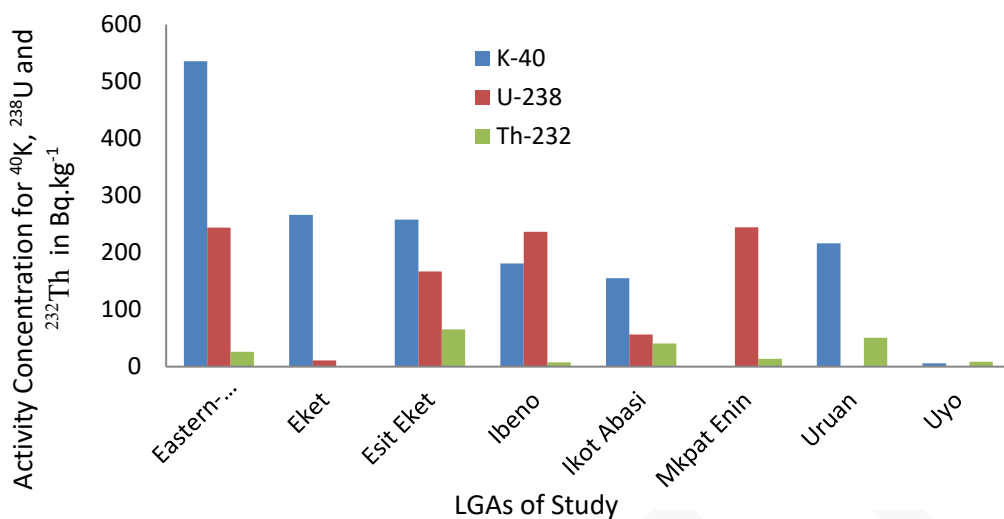


Figure 1: The distribution of the activity concentrations for ^{40}K , ^{238}U and ^{232}Th in Bq.kg⁻¹ for soil samples from the study areas.
Source: The researcher (2026)

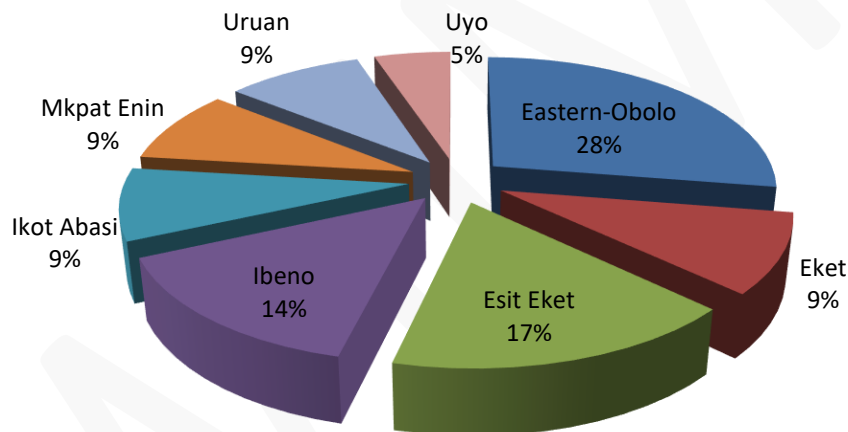


Figure 2: Percentage distribution of the combined radionuclides (^{40}K , ^{238}U and ^{232}Th) concentration for soil samples from the study areas.
Source: The researcher (2026)

4. Discussion

The activity concentration of ^{40}K , ^{238}U and ^{232}Th for the soil samples gotten from the locations are presented in Table 1. From Table 1, ^{40}K , the activity concentration ranged from BDL (below detection limit) to 535.6 ± 34.03 Bq.kg⁻¹ with a mean of 202.3 ± 12.8 Bq.kg⁻¹ for ^{238}U , it ranged from BDL to 244.6 ± 39.84 Bq.kg⁻¹ with a mean of 120.1 ± 9.53 Bq.kg⁻¹. For ^{232}Th , the activity concentration ranged from BDL to 50.6 ± 3.66 Bq.kg⁻¹ with a mean of 26.6 ± 1.55 Bq.kg⁻¹. Eastern Obolo has the highest activity concentration for ^{40}K with a value of 535.6 ± 34.03 Bq.kg⁻¹, Mkpato Enin and Esit Eket has the highest activity concentration for ^{238}U and ^{232}Th respectively with a value of 244.6 ± 39.84 Bq.kg⁻¹ and 65.2 ± 4.72 Bq.kg⁻¹, respectively. Since the earth formation, natural occurring radionuclides have been present as a result of different

concentrations of heavy metals present in the soil. The high values of radionuclides concentration in these areas is due to the large amount of natural radionuclide present in the crude oil waste released in those areas and also as a result of the large deposit of hydrocarbon in these areas (Ogbalagba *et al.*, 2013) (UNSCEAR, 1993). The mean values of radionuclides concentration obtained in this study are greater than that obtained (136.9 ± 3.66 , 21.8 ± 2.32 and 18.9 ± 0.62 Bq.kg⁻¹) in the work of Bede *et al.* (2015). Figure 1 shows that Eastern Obolo has the highest distribution of ⁴⁰K in the soil samples while Uyo has the least. From Figure 2, Eastern Obolo has the highest percentage distribution of the combined radionuclide in the soil samples with a percentage of 29% while Uyo has the lowest of 5%.

References

- Al-Haydari, A., Al Sharabi, E. S., & Al Buhairi, M. H. (2012). Determination of specific activity of ^{226}Ra , ^{232}Th and ^{40}K for assessment of environmental hazards. *Radiation protection dosimetry*, 148(3), 329-336.
- Baldock, D., Doran, S., Ibbott, G., Jirasek, A., Lepage, M., Mcauley, K. B., Oldham, M. and Schreiner, L. J. (2010). Polymer gel dosimetry. *Physics in Medicine and Biology*, 55 (5): 10-16
- Chen, S. B., Zhu, Y. G. and Hu, Q. H. (2005). Soil to plant transfer of ^{238}U , ^{226}Ra and ^{232}Th on uranium mining-impacted soil from southeastern China. *Journal of Environmental Radioactivity*, 82(2): 213-216. Doi: 10.1016/j.jenvrad.2005.01.009.
- Ghazwa A., Fauziah B. S., Rahman I. A. (2016). Assessment of natural radioactivity levels and radiation hazards in agricultural and virgin soil in the State of Kedah, North of Malaysia. *The Scientific World Journal*. 2016: 9 pages. Available at: <http://dx.doi.org/10.1155/2016/6178103>. Accessed from PUBMED on 12th June, 2021.
- Jibiri, N. N, Alausa, S. K and Farai, I. P (2007). Assessment of external and internal doses due to farming in high background radiation areas in old tin mining localities in Jos-Plateau, Nigeria. *Radioprotection* 44 (2) 139 – 151
- Ogbalagba, E. O., Avwiri, G. O. and Chad-Umoren, Y. E. (2013). Radiological impact of oil and gas activities in selected oil fields in production land areas of Delta State. *Nigeria Journal of Applied Science and Environmental Management*, 17 (2): 279-288.
- UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) (1993). Sources and effects of ionizing radiation. New York, USA: Available from: <http://www.unscear.org/docs/publications/1993/UNSCEA>
- UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) (2000). *Sources, effects and risks of ionizing radiation*. Report to the General Assembly. ISBN 92-1-142238-8, New York.
- Wohlers, A., Wood, B. J. (2015). A Mercury-like component of early earth yields uranium in the core and high mantle ^{142}Nd . *Nature*. 520 (7547): 337-340. Doi:10.1038/nature14350. PMC 4413371 Pubmed.