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Full Length Research Article

ESTIMATION OF GROSS ALPHA AND GROSS BETA RADIOACTIVITY IN SOILS WITHIN COASTAL AREA OF NIGER DELTA, NIGERIA

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ABSTRACT
This investigation aims to estimate the levels of gross α and β radioactivity in soils from the Niger Delta, a region impacted by extensive oil drilling activities. Soil samples were taken from fifteen (15) locations, and radiation measurements were made using a gas-flow proportional counter. The results indicated a range of alpha activity concentrations from 1.908 to 19.09 Bq/kg, with an average of 7.725 ± 4.79 Bq/kg, and beta activity concentrations from 448.0 to 4098.0 Bq/kg, with an average of 1749.8 ± 319.6 Bq/kg. Compared to the control values, the observed radiation levels were notably elevated. Observed patterns also showed a moderate positive correlation between α and β activities, indicating the impact of common sources or environmental influences. While the radiation levels observed align with those reported in some similar studies, the study recommends continued monitoring due to potential long-term environmental and health impacts, especially given the elevated beta radiation concentrations.

Keywords: Niger Delta, Gross Alpha, Gross Beta, Soil Contamination, Radioactivity, health effects.

INTRODUCTION
Radiation is an inevitable aspect of the Earth's natural processes, and its presence is felt everywhere, from the soil beneath our feet to the atmosphere surrounding us. Although radiation is frequently linked to nuclear energy and related incidents (Ohba et al., 2024), it is essential to understand that it also exists as a natural component of the environment (Cerrito, 2017), contributing significantly to ecological equilibrium. Soil contains gross alpha radioactivity from sources like ^{226}Ra and gross beta radioactivity primarily from naturally occurring isotopes such as ^{40}K, ^{210}Pb, and ^{228}Ra (Ferdous, 2012; Ilori and Chetty, 2024; Salman & Hassan, 2024). These naturally occurring materials contribute to widespread, low-level radiation exposure across ecosystems.
Anthropogenic activities have further amplified environmental radiation levels through nuclear weapons testing, medical imaging, industrial applications, and radioactive waste disposal (Aswal, 2024; Hatra, 2018; Esi, 2025). The oil and gas industry also contributes via the release of naturally occurring radioactive materials (NORM), waste from drilling, flare emissions, and the use of depleted uranium in equipment (Phiona, 2020; Wiescher, 2025; Esi et al., 2024). Gross alpha and beta radiation in the environment primarily stem from these natural and anthropogenic sources (May and Schultz, 2021), each contributing to varying degrees of radioactivity in ecosystems, with soils being a primary reservoir. These types of radiation are categorized by the type of particles they emit: alpha (α) particles, which are heavier and positively charged, and beta (β) particles, which are lighter and negatively charged (electrons). Both alpha and beta radiation can be hazardous to living organisms, especially when exposure occurs over extended periods (Esi, 2025; Riudavets et al., 2022).
Although alpha radiation has low penetration ability and cannot pass through the skin, it poses a risk when the body inhales, ingest, or absorb alpha-emitting substances through cuts or open wounds (Colwell, 2013; Esi et al., 2023). Once absorbed by the body, alpha particles can lead to significant damage to internal tissues and cells (De Kruijff et al, 2015). For example, radon gas, a significant source of alpha radiation, poses a major health risk when inhaled such as lung cancer (Ponciano-Rodríguez, 2021; Riudavets et al., 2022; Verma, 2025; Nwodo, 2025). On the other hand, Ojha et al, (2022) stated that Beta radiation has greater penetration power than alpha radiation and can penetrate the outer layer of skin, potentially causing skin burns or eye damage when exposure is prolonged. In cases of internal exposure, beta particles can damage deeper tissues and organs, increasing the risk of cancers, particularly in the bone and thyroid (Feldman, 2023).
Soil contaminated with radioactive particles can cause significant ecological and health issues. Radioactive substances, including alpha and beta particles, can be taken up by plants, which are ingested by herbivores leading to biomagnification in the course of food chain, impacting higher levels, such as carnivores, livestock, and humans. (Shah and Kumar, 2022; Esi and Akpoyibo, 2023; Cleveland et al., 2022). This contamination can also degrade soil quality by altering its pH, microbial activity, and nutrient availability, impairing soil fertility and hindering plant growth (Selvakumar et al., 2018). Human exposure to radiation from contaminated soil can occur through inhalation of dust particles or ingestion of contaminated food, water, or soil (Einstein, 2023; Sandil and Kumar, 2022). The analysis of gross α and β content in soil plays a vital duty in understanding the presence and distribution of radiation in the location. Measuring the radioactivity levels in various matrices is crucial for ensuring radiation exposure stays within safe limits and for evaluating the overall environmental impact of radiation. This study aims to measure the gross α and β activities in different soil samples from the region to determine the magnitude of radioactivity in these materials.

MATERIALS AND METHODS
Study Area
The study area is located within the latitude 4º 17" N and 4º 51" N and longitude 5º 31" E and 7º42" E coordinates of the Niger Delta region in Delta State, Nigeria. The total area covers 112,000 km² with a population of over 30,000,000 million people according to the 2006 census (Ike and Emaziye, 2012). The presence of crude

oil has attracted significant attention from both national and international corporations, leading to widespread extraction activities in the area. The local population primarily engages in agriculture, relying on fertile land to cultivate crops. This research is focused on analyzing the effects of gross alpha and gross beta radioactivity in soil samples from the area.

Sample Collection and Preparation Techniques

The procedure followed in this study involved stratified random sampling techniques (Boschetti et al., 2016). An Etrex Garmin GPS meter was used to obtain coordinates and locations of the sampling points (Tien Bui., et al., 2015). Soil samples were dug from fifteen predefined coordinate locations across the study area with a prepared hand auger, following world scientific method (Nielsen., 2005). Thereafter, the hand auger was used to collect soil samples from 0 to 15 cm depth, corresponding to the topsoil layer (Margesin and Schinner, 2005), with stones in the Niger Delta, vegetation, and organic material carefully removed. The samples were prepared in accordance with international procedures and place in a well prepared and labeled black polythene bags before transporting it to the laboratory. The samples were further stored in drying cabinet at 50°C temperature to ensure no loss of radionuclides. Thereafter, the samples were grounded with a mortar and pestle, homogenized by passing through a 100mm-mesh sieve to ensure better sample homogeneity and detection sensitivity.

Measurement of gross α and β activities

The measurements were conducted at the Centre for Energy, Research and Training (CERT), at Ahmadu Bello University, Zaria. The concentration of gross α and β activity in the prepared soil samples was measured using IN-20 model gas-flow proportional (GFP) counter, with window thickness of approximately 450 μg cm^{-3} and a diameter of 60 mm. The GFP counter was linked to graphic software that has spreadsheet and microprocessor, and position in flexible lead shielding to block radiation. The GFP counter channel efficiency was determined to ascertained background radiation of the surrounding (Selvakumar et al., 2018). An blank planchette was clean and dried to eliminate any residual contaminants or moisture, which could affect the count rate (Damla et al., 2025). The count rate was then recorded over a specified period to ensure accurate background data. During counting, the (GFP) counter was configured to a mode according to the particle to be detected alpha-only and beta-only with a bias voltage of approximately 1100V and 1700V respectively. The samples were counted for 13 cycles and 25 cycles respectively for alpha and beta each lasting 180 seconds. A scatter plot was created from the counting data, displaying the counts versus the eight channels measured simultaneously. The specific activities were determined using the following expression (Jibiri and Fasae, 2012):

$$\text{Specific Activity } (A_\alpha) = \frac{(CR_\alpha - background\ CR_\alpha)}{(chennel\ alpha\ efficiency)\times(sample\ efficiency)\times(sample\ volume)} \quad 1$$

$$\text{Specific Activity } (A_\beta) = \frac{(CR_\beta - background\ CR_\beta)}{(chennel\ beta\ efficiency)\times(sample\ efficiency)\times(sample\ volume)} \quad 2$$

RESULTS AND DISCUSSION

The specific activities of gross α and β radiation in soil samples were determined for radioactive contamination levels and the mean results are presented in Table 1.

Table 1: The mean results of Gross α and β Activity concentration in Soil samples

S/No	Samples	α -Activity (Bq/kg)	β –Activity (Bq/kg)
1	Soil1	10.26±6.41	1420.9±399
2	Soil2	18.12±8.85	3819.0±439.5
3	Soil3	4.362±3.30	1095.2±234
4	Soil4	5.253±3.92	1456.5±303
5	Soil5	10.93±5.09	1590.0±321
6	Soil6	5.970±4.41	2217.0±313
7	Soil7	4.544±339	856.6±260
8	Soil8	8.444±3.96	448.0±268
9	Soil9	1.908±2.75	1477.9±238
10	Soil10	6.662±3.56	1355.5±223
11	Soil11	8.18±4.65	1255.3±322
12	Soil12	3.561±353	1204.9±323
13	Soil13	3.977±3.79	3272.0±233
14	Soil14	19.09±9.85	4098.0±569
15	Soil15	4.610±4.39	680.5±348
Average		7.725±4.79	1749.8±319.6
Control		3.042±0.61	158.2±6.44

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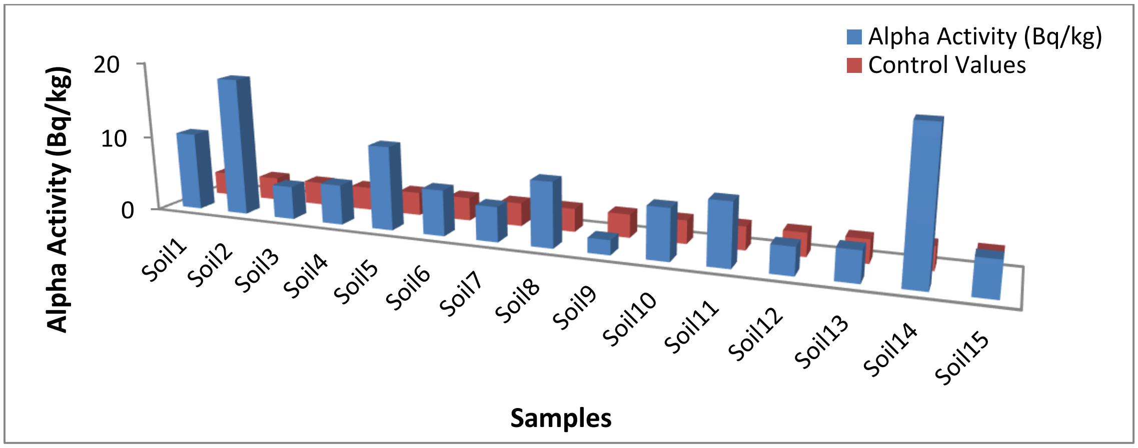

Figure 1: Relationship between the mean values of α activity with Soil control (Bq/kg)

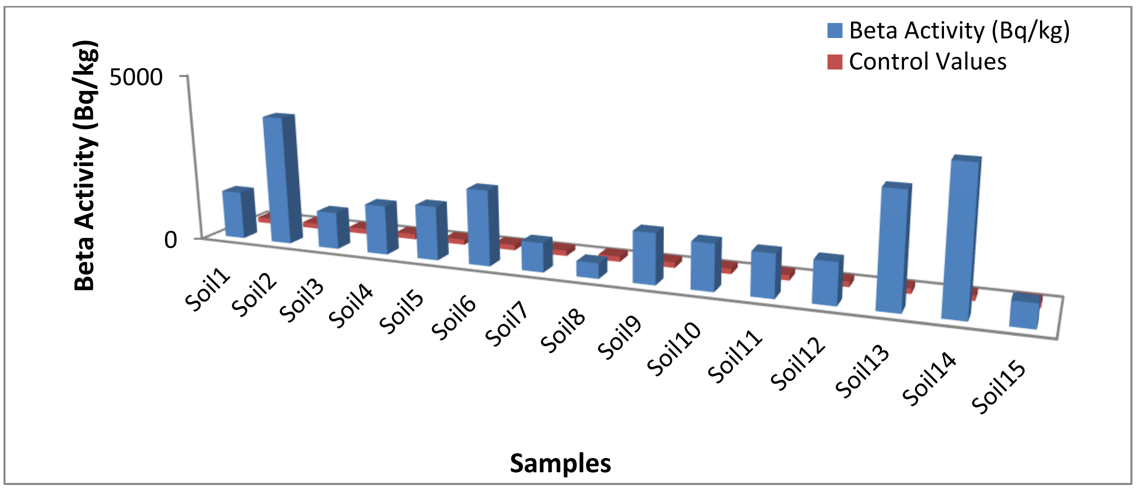

Figure 2: Relationship between the mean values of β - activity with Soil

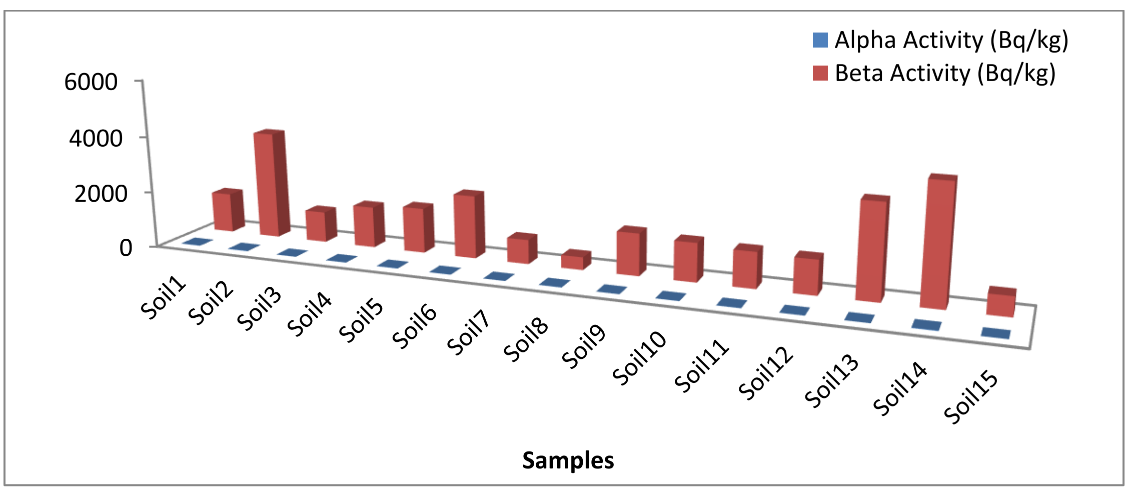

Figure 3: Relationship between the mean values of α and β activity (Bq/kg)

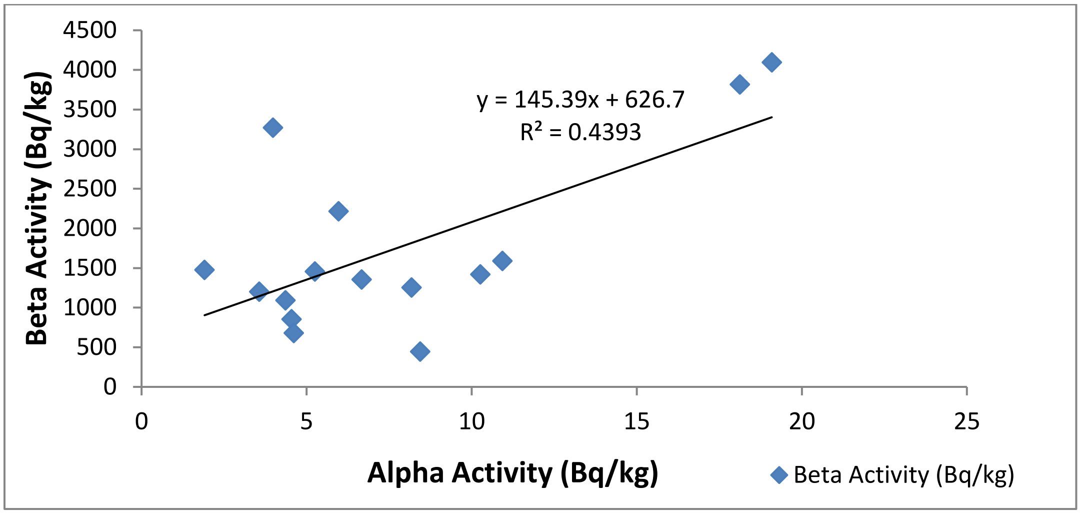

Figure 4: Correlation relationship between the mean values of α and β activity

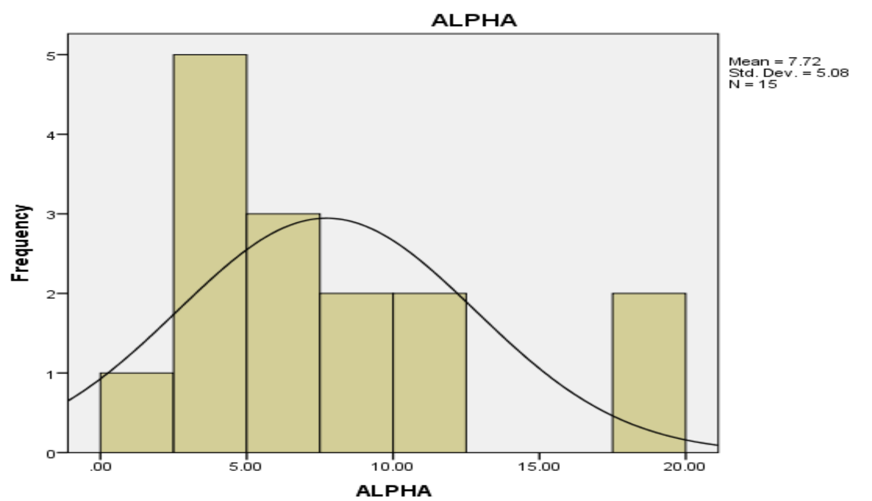

Figure 5: Frequency distribution of Gross α in Soil Samples

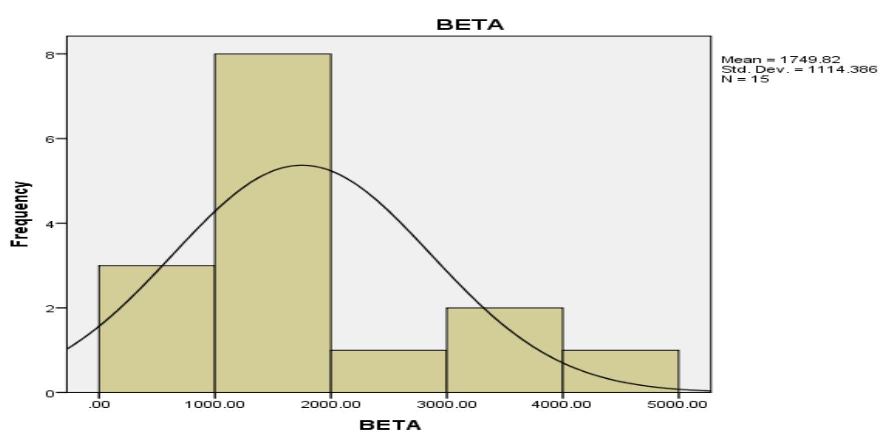

Figure 6: Frequency distribution of Gross β in Soil Samples

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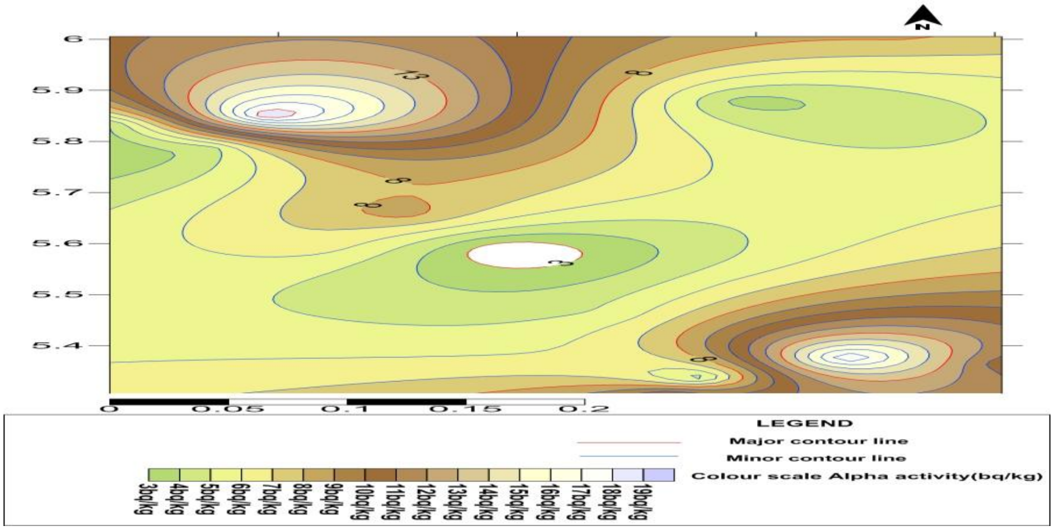

Figure 7: Contour map of gross α Activity concentrations for Soil Sampled

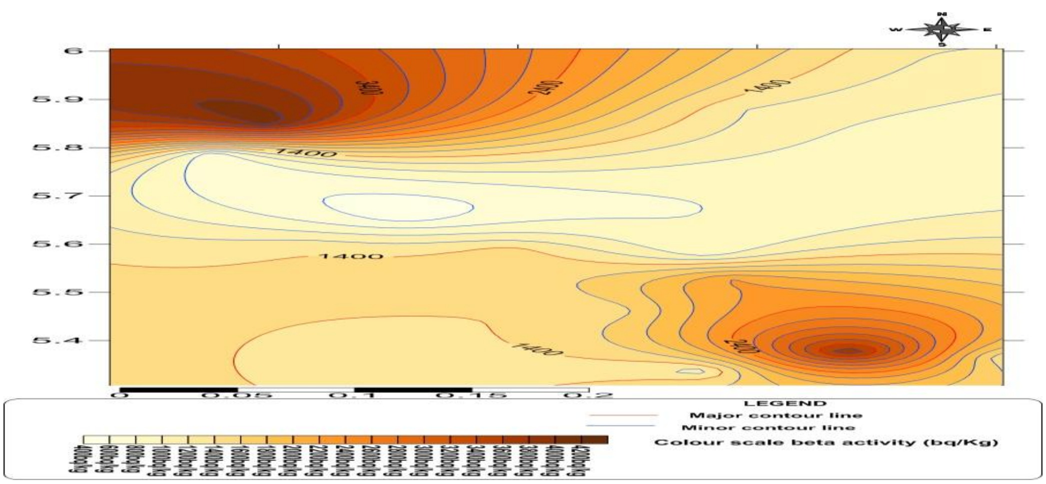

Figure 8: Contour map of gross β activity concentrations for soil sampled

The α activity concentrations ranged from the 1.908 Bq/kg (Soil9) to 19.09 Bq/kg (Soil14) with mean of 7.725 ± 4.79 Bq/kg. The β activity concentrations ranged from 448.0 Bq/kg (Soil8) to 4098.0 Bq/kg (Soil14) with mean of 1749.8 ± 319.6 Bq/kg. Soil14 recorded the highest values for both alpha and beta activities with 19.09 Bq/kg and 4098.0 Bq/kg, respectively. The control sample recorded **3.042 ± 0.61 Bq/kg** and **158.2 ± 6.44 Bq/kg for both** gross α and β activity concentrations respectively. Figure 1 and 2 showed comparison statistical bar chart analysis, indicating that the measured gross α and β concentrations values exceeded the control measured gross α and β values. Also, the gross α and β activity concentrations values compared indicate elevation in beta radiation levels in the study area as shown in figure 3. These are shown that the β -emitting radionuclides are dispersed by both human interventions such as excavation, drilling and natural forces like water and wind. As these β-emitting isotopes disperse over larger areas, the concentration of beta activity tends to be higher in the studied samples. Figure 4 shows the coefficient of the correlation as $R^2 = 0.43$ between α and β activity concentrations, indicating a moderate positive correlation between the two variables. This is supported by the corresponding results from the linear regression equation $y = 145.3x + 626.7$ which also indicates a positive relationship between α and β activity in the soil. Specifically, for every unit increase in α-activity, β-activity is expected to increase by 145.3 Bq/kg. An upward trend in beta activity appears to accompany higher alpha activity levels, albeit not in a perfectly linear fashion. This indicates that the correlation, while present, may be influenced by other environmental variable

Table 2: Show gross α and β activity comparison with other studies

Ranged of Gross alpha (Bq/kg)	Ranged of Gross beta (Bq/kg)	Reference
0.35 to 0.53	0.46 to 1.04	Amakom et al., 2018.
48.5 to 64.0	411.5 to 2710.0	Ogundare and Adekoya., 2015.
152.11 to 322.0	311.15 to 615.5	Anekwe et al., 2013.
2.7 to 17	12.5 to 237.9	Uchenna et al., 2019.
BDL to 585.73	142.82 to 2570.703	Sindhu et al., 2017
1.908 to 19.09	448.0 to 4098.0	Current study

A comparative analysis of current study with previous reports is shown in Table 2. It is evident that β activity concentrations tend to surpass α concentrations; this may be explained by the greater range and penetration of β particles in matter and air. Because of their greater mobility, beta-emitting radionuclides can accumulate in larger quantities in certain environmental media. These findings also indicate that the gross alpha concentrations in the present study were on the lower end of the spectrum or comparable when compared to these referenced studies. This might suggest a reduced risk of radiation exposure; however, even lower levels of radiation can still pose health risks over extended periods, especially in occupational settings where workers are continuously exposed to these materials. The long-term cumulative effect of even low-level radiation can increase the risk of cancer and other health conditions. The α and β sources in studied soil may also be traceable to minerals containing radioactive material such as hydrocarbon, been explored in the area as indicated in the bell-shaped degree of multi-modality as shown in histograms frequency distributions of soil in figure 5 and 6. The dense and the less dense regions of the contour maps as shown in figure 7 and figure 8 indicate the concentrations regions, with the much dense region showing the contamination region while the less dense region shows the less contamination region of the studied area. This also indicates log-normal form of multimodality intensity of gross α and β activity of soil in the studied area.

Conclusion
The gross α and β activity concentrations in the study area were determined using α/β spectroscopy. The results obtained from the measurement of gross α and β activity in soil samples indicated that while the gross α activity concentrations were relatively moderate and in line with similar studies, the gross β activity concentrations were significantly higher compared to most of the referenced studies. This suggests that β-emitting radionuclides are more prevalent or dispersed in the environment, potentially due to factors such as the mobility of β-emitting isotopes and human activities in the study area. The elevated beta concentrations, particularly in comparison to the control values, suggest that the area may have a higher level of β radiation than expected. However, the overall radiation burden, considering α and β activities, remains within the limits of other similar studies. Continuous monitoring is recommended to assess any potential long-term environmental and health implications associated with the observed beta radiation levels.

REFERENCE

Amakom, C. M., Orji, C. E., Eke, B. C., Iroegbu, C., and Ojakominor, B. A. (2018). Gross alpha and beta activity concentrations in soil and some selected Nigerian food crops. *International Journal of Physical Sciences*, *13*(11):183-186. https://doi.org/10.5897/IJPS2018.4719

Anekwe, U. L., Avwiri, G. O., and Abumere, O. E. (2013). Evaluation of the gross alpha and beta radionuclide activity within some selected oil producing fields in rivers state, Nigeria**.** *American Journal of Scientific and Industrial Research*, *4*(6):546-554. https://doi.org/10.5251/ajsir.2013.4

Aswal, D. K. (2024). Handbook on Radiation Environment*, Volume 1: Sources, Applications and Policies*. Springer Nature.

Boschetti, L., Stehman, S. V., and Roy, D. P. (2016). A stratified random sampling design in space and time for regional to global scale burned area product validation. *Remote sensing of environment*, *186*, 465-478. https://doi.org/10.1016/j.rse.2016.09.016

Cerrito, L. (2017). Natural Sources of Radiation. In *Radiation and Detectors: Introduction to the Physics of Radiation and Detection Devices* (pp. 19-36). Cham: Springer International Publishing.

Cleveland, D., Hinck, J. E., and Lankton, J. S. (2021). Elemental and radionuclide exposures and uptakes by small rodents, invertebrates, and vegetation at active and post-production uranium mines in the Grand Canyon watershed. *Chemosphere*, *263*,:127-908.

Colwell, C. B. (2013). Radiation injuries. *Rosen's emergency medicine: concepts and clinical practice E-book. Elsevier Health Sciences. https://books. googl e. com. tr/books*.

Damla, N., Yesilkanat, C. M., Kaya, R., Taskin, H., Isık, U., and Aldemir, K. (2025). Radiological health risk maps of drinking water in Diyarbakır city, Türkiye. *International Journal of Environmental Health Research*, 1-17. https://doi.org/10.1080/09603123.2025.2482067

De Kruijff R. M., Wolterbeek, H. T., and Denkova, A. G. (2015). A critical review of alpha radionuclide therapy—how to deal with recoiling daughters?. *Pharmaceuticals*, *8*(2), 321-336. https://doi.org/10.3390/ph8020321

Einstein, O. P. (2023). Cancer Risks Associated With Exposure To Background Ionizing Radiation In Human Habitat, Soil, And Food In Kenya (Doctoral Dissertation, Kenyatta University). De Kruijff

Esi E. Oghenevovwero, Akpoyibo Ogheneovo, Nwankwo Rufus Chigozie, Vwavware Oruaode Jude (2023) Estimation of the variability of sand deposits in chosen communities in parts of Niger delta, Southern-Nigeria using geophysical techniques, Solid Earth Sciences 8 (4), 267-282

Esi EO and Akpoyibo O. (2023) Estimation Of Aqufer Transmissivity For Typical Oil Producing Communities of Western Niger Delta Using Electrical Resistivity Survey, Coast Journal of the School of Science OAUSTECH Okitipupa 5 (2), 893-908

Esi Oghenevovwero E., Avwiri Gregory O., Sylvanus Onjefu A., and Onwudiwe Damian C. (2024) Radiometric survey of sediments and health risk assessments from the southern coastal area of Delta State, Nigeria. *Heliyon* 10: 1 – 15, e26805

Esi Oghenevovwero E (2025) Gross alpha and beta radioactivity in crude oil-contaminated sediments of southern Delta State, Nigeria, FUDMA Journal of Sciences (FJS), 9 (2): 140 – 146. https://doi.org/10.33003/fjs-2025-0902-3265

Esi Oghenevovwero, E., Agbalagba, E. O., and Avwiri Gregory, O. (2021). Impact of produced water discharge on the gross alpha and gross beta activity concentrations and radiological health risk on drinking water sources in coastal areas of Nigeria. *International Journal of Ambient Energy*, *42*(1): 18-28. https://doi.org/10.1080/01430750.2018.1525577

Feldman, R. J., Kazzi, Z., and Walter, F. G. (2023). Radiation injuries: acute radiation syndrome in children. *Pediatric annals*, *52*(6), e231-e237. https://doi.org/10.3928/19382359-20230411-03

Hatra, G. (2018). Radioactive pollution: An overview. *The holistic approach to environment*, *8*(2):48-65. https://hrcak.srce.hr/202085

Ike P.C and Emaziye P.O (2012) An Assessment of the Trend and Projected Future Values of Climatic Variables in Niger Delta Region, Nigeria, Asian Journal of Agricultural Sciences 4(2): 165-170

Ilori, A. O., and Chetty, N. (2024). A review of the occurrence of naturally occurring radioactive materials and radiological risk assessment in South African soils. *International Journal of Environmental Health Research*, *34*(8) :2969-2982.

Jibiri NN and Fasae KP (2012). Activity concentrations of 226Ra, 232Th and 40K in brands of fertilisers used in Nigeria. Radiation Protection Dosimetry 148(1):132-137 https://doi.org/10.1093/rpd/ncq589

Margesin, R., and Schinner, F. (Eds.). (2005). *Manual for soil analysis-monitoring and assessing soil bioremediation* (Vol. 5). Springer Science & Business Media.

May, D., and Schultz, M. K. (2021). Sources and health impacts of chronic exposure to naturally occurring radioactive material of geologic origins. *Practical Applications of Medical Geology*, 403-428.

Nielsen, G. L. (2005). Decontamination of Field Equipment Used in Environmental Site Characterization and Ground-Water Monitoring Projects. In *Practical Handbook of Environmental Site Characterization and Ground-Water Monitoring* (pp. 1273-1290). CRC Press.

Nwodo, V. K., Ezenma, I. C., Geofery, L., Abubakar, M. G., Nwodo, M. C., Chiegwu, H. U., and Nwodo, C. U. (2023). Awareness Of Potential Ambient Radon Gas Inhalation Hazards Among Undergraduate Students And Staff Of A Medical School In South-East, Nigeria. *Journal of Biomedical Investigation*, *11*(2), 73-85.

Ogundare, F. O., and Adekoya, O. I. (2015). Gross alpha and beta radioactivity in surface soil and drinkable water around a steel processing facility. *Journal of radiation research and applied sciences*, *8*(3): 411-417. https://doi.org/10.1016/j.jrras.2015.02.009

Ohba, T., Tanigawa, K., and Liutsko, L. (2021). Evacuation after a nuclear accident: Critical reviews of past nuclear accidents and proposal for future planning. *Environment international*, *148*: 106--379. https://doi.org/10.1016/j.envint.2021.106379

Ojha, H., Choudhary, V., Sharma, D., Nair, A., Sharma, N., Pathak, M., and Goel, R. (2022). Medical management of ionizing radiation-induced skin injury. *Radiation Protection and Environment*, *45*(1), 2-15.

Phiona, N. (2020). Enforcement And Compliance with Laws of Radioactivity Emissions and Its Implications in the Oil and Gas Exploration and Production Sector in Uganda (Doctoral dissertation, Institute of Petroleum Studies-Kampala).

Ponciano-Rodríguez, G., Gaso, M. I., Armienta, M. A., Trueta, C., Morales, I., Alfaro, R., and Segovia, N. (2021). Indoor radon exposure and excess of lung cancer mortality: The case of Mexico—An ecological study. *Environmental geochemistry and health*, *43*, 221-234.

Riudavets, M., Garcia de Herreros, M., Besse, B., and Mezquita, L. (2022). Radon and lung cancer: current trends and future perspectives. *Cancers*, *14*(13), 3142.

Salman, J. E., and Hassan, N. M. (2024). Evolution of radionuclide concentration and the radiological hazards in building material: a review. *Journal of Taibah University for Science*, *18*(1) :2370588.

Sandil, S., and Kumar, R. (2022). Soil contamination from construction projects. *Ecological and health effects of building materials*, 205-244.

Selvakumar, R., Ramadoss, G., Menon, M. P., Rajendran, K., Thavamani, P., Naidu, R., and Megharaj, M. (2018). Challenges and complexities in remediation of uranium contaminated soils: A review. *Journal of environmental radioactivity*, *192*: 592-603.

Shah, S., and Kumar, A. (2022). Bioavailability, Bioconcentration, and Biomagnification of Pollutants. In *Environmental Toxicology and Ecosystem* (pp. 179-214). CRC Press.

Shehata, S. A., Toraih, E. A., Ismail, E. A., Hagras, A. M., Elmorsy, E., and Fawzy, M. S. (2023). Vaping, environmental toxicants exposure, and lung cancer risk. *Cancers*, *15*(18), 4525.

Sindhu, S., Roselin, M. S. U., and Shanthi, G. (2017). Estimation of Activity Concentration of Uranium and Thorium Using Gross Alpha and Gross Beta in Agricultural Soils in Kanyakumari District. *SSRG International Journal of Agriculture & Environmental Science*, *4*(2): 28-35.

Tien Bui, D., Tran, C. T., Pradhan, B., Revhaug, I., and Seidu, R. (2015). iGeoTrans–a novel iOS application for GPS positioning in geosciences. *Geocarto International*, *30*(2), 202-217.

Uchenna, M. M., Mmaduabuchi, O. C. and Osaretin, B. S. (2019). Assessment Of Gross Alpha, Gross Beta Radioactivity And Heavy Metals Concentration In Soil Samples In Wukari, Taraba State. *European Journal of Physical Sciences*, *1*(1): 59-68.

Verma, D. K., Rameshwari, R., and Meena, J. (2025). Health and environmental risk of alpha emitter radium. In *Hazardous Chemicals* (pp. 713-722). Academic Press.

Wiescher, M. (2025). *Radioactivity: Anthropogenic Sources*. CRC Press.