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Gross Alpha and Gross Beta Activity Concentrations in Living Stone Potato in the Mining and Non-Mining Areas of Barkin-Ladi, Plateau State

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Abstract:- The gross alpha and gross beta activity concentration in Living-stone Potato (Plectranthus esculentus), obtained in selected mining and non-mining areas of Barkin-Ladi, Plateau state have been determined. Sample tubers of Living-stone Potato were collected from mining and non-mining areas using a random sampling approach. The samples were taken directly from the farm and examined at Ahmadu Bello University's Centre for Energy Research and Training (CERT) in Zaria using a gas-filled proportional counter (MPC 2000 dual phosphor detector) with alpha and beta background of 0.5 cpm and 0.73 cpm, respectively. The results show that alpha activity in sample areas ranged from 0.005306 $\pm$ 0.00793 Bq/g to 0.03535 $\pm$ 0.00142 Bq/g with an average value of 0.03255 $\pm$ 0.00701 Bq/g. The gross alpha activity concentration was determined to be higher in the mining locations. The beta activity concentration ranges from 0.00349 $\pm$0.0198 to 0.01397 $\pm$ 0.0198 Bq/g, with an average value of 0.03622 $\pm$ 0.00196 Bq/g. The greatest value of 0.01397 $\pm$ 0.0198 Bq/g was reported in the mining area. The lowest value was recorded below the detection limit of the machine utilized. Interestingly, all of the activities examined (alpha and beta) were found to be below the World Health Organization (WHO) recommended consumption values of 0.1 Bq/g and 1.0 Bq/g for alpha and beta, respectively. The rise in alpha and beta activity that has been observed in mining areas may be associated with the quality of irrigation water, local human activities like mining around farms, and fertilizer use in farming. The public consuming these products, however, may not be adversely affected by the outcomes in a significant way.

Keywords:- *Gross Alpha, Gross Beta, Activity, Concentration, Radioactivity.*

I. INTRODUCTION

Natural radionuclides have existed since the earth's origin, and radionuclides enter the soil through weathering. The amount of radiation to which man is constantly exposed is accounted for by the existence of radionuclides in the environment (Ajayi, 2009). All plants, including the living stone potato (Plectranthus esculentus), reside within the earth. Ionizing radiation is produced by the decay of radioactive elements in the environment, which can come from both artificial and natural radionuclide sources. Ionizing radiation is present in the air we breathe, the food we consume, and the water we drink. Despite the fact that ionizing radiation and radioactivity are a part of the environment on a natural basis, human activities like mining and the use of organic fertilizers in agriculture raise the amount of ionizing radiation in the environment (Inyang et al., 2009).Long-term exposure to these ionizing radiations has been experienced by mining personnel as well as nearby residents who live near the mining site (Sadiq et al., 2010). Concern over radiation exposure from natural sources has spread over the world, prompting several nations and experts to estimate the degree of radiation exposure to people. As a result, environmental management and protection have come under the spotlight in human society in an effort to ensure that organisms are protected from the effects of ionizing radiation (United Nations Scientific Committee on the Effects of Atomic Radiation, 2010a)

The radionuclides that occur naturally are the offspring of uranium and thorium isotopes, such as ^{40}K, whereas those that occur artificially can come from minute amounts of fission product residues, such as ^{137}Cs from atmospheric bomb tests (Guidebook, 1989). A reliable source of food for Africa is roots and tubers, which are significant tropical crops. These include cassava, yam, cocoyam, potato, living stone potato, and many others ((Aboloma et al., 2009).

The presence of natural radionuclides in root and tubers, including living stone potatoes, may depend on the type of soil, the rate at which radionuclides are transferred from roots to tubers, the quality of irrigation water, and local human activities like mining around the farm environment and the use of fertilizers in farming. Natural radionuclides are nuclides that continuously emit radioactive particles like alpha, beta, and gamma and are harmful to our health if the emission dose is large in the crops we consume. The environment is full of naturally occurring alpha emitters. For instance, radionuclides that are found in various concentrations in almost all rocks, soils, and water, such as uranium-238, radium-226, and other members of the naturally occurring uranium, thorium, and actinium decay series, release alpha particles. The radioisotopes that make up the uranium, thorium, and actinium natural radioactive

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decay chains naturally contain a large number of beta emitters. Lead-210, bismuth-214, and thallium-206 are a few examples (Bonotto et al., 2009). When ingested, a decaying natural radionuclide may emit numerous radioactive particles and harm live cells. Increased ionizing radiation exposure may result in cell transformation due to DNA damage (Santivasi & Xia, 2014). Radiation is increased by practices including overgrazing, mining, and farming. Jibiri, Farai, and Alausa (2007)

Mining activities expose the interior soil to the earth's surface. This internal soil may contain harmful radionuclides such as ^{238}U, and ^{226}Ra, which are alpha emitters, as well as ^{228}Ra, and ^{210}Pb, which are beta emitters. When farming is practiced in these areas, plants are compelled to absorb these radionuclides, and when consumed, this can result in health issues like leukemia chromosomal breakage, bone necrosis, bone cancer, gene mutations, cataracts of the eye lens, and other issues (Agba et al., 2006).

In order to determine the radiological food safety of the people living in the Bitsichi area of the Plateau, Nigeria, (Jibiri et al., 2007) collected several crops that comprise the major food nutritional requirement directly throughout farmlands in the vicinity. Using γ -ray spectrometry, the activity concentrations of ^{226}Ra, ^{228}Th, and ^{40}K in food and soil samples were determined. In addition, on the farms, in situ gamma radiation rate measurements were taken using a pre-calibrated survey meter. The equivalent activity concentrations in food crops ranged from BDL to 684.5 Bq kg-1 for ^{40}K, BDL to 83.5 Bq kg-1 for ^{226}Ra, and BDL to 89.8 Bq kg-1 for ^{228}Th. Cereals had lower activity concentrations of these radionuclides than tubers and vegetables. The results indicate that the dose from radionuclide ingestion by food crops is modest and that adverse health effects are unlikely.

Using γ-ray spectrometry, Jwanbot, D.I et al., (2012) determined the activity Concentration of ^{40}K, ^{226}Ra, and ^{228}Th in the food crops on the Jos Plateau. For 40K, the natural radionuclide activity concentration ranged from 12.36 ± 0.82 to 56.92 ± 8.84 Bq/Kg; for 226Ra, it was 1.46 ± 0.05 to 10.42 ± 0.04) Bq/Kg, and for 228Th, it was 1.53 ± 0.08 to 6.85 ± 0.42 Bq/Kg. The series of tin mining operations that have occurred in these locations over the previous few decades was blamed for the relatively high results for the activity concentrations. Nonetheless, the results indicate that there is little risk of adverse consequences and that the dose absorbed from consuming these radionuclides in food crops is minimal.

(Irunkwor et al., 2022) evaluated the radiological hazard and natural radioactivity indices associated with the consumption of cassava crops grown in five communities within Rivers State that have a history of oil spills, gas flaring, oil bunkering, and illegal artisanal oil refining operations. Samples of soil and cassava crop were taken from each of the five localities. The collected results were utilized to assess the soil-to-cassava transfer factor (TF) resulting from local residents' consumption of staple foods and cassava crops. The mean activity of the cassava samples was found to be higher than that of the control samples and the internationally allowed limits. It ranged from 6.50±1.30Bq/kg to 29.70±6.20Bq/kg for 238 U, 5.80±2.20Bq/kg to 16.50±6.80Bq/kg for 232 Th, and 383.20±28.10Bq/kg to 482.30±35.80Bq/kg for 40 K. The results of the study showed that although some of the radiological hazard indices in the cassava samples were below allowable limits, eating cassava crops or staple foods increases the estimated committed annual effective dose and excess lifetime cancer risk by more than 2.9 and 5.9 times, respectively, over the international permissible limit of 0.29mSv/y. The mean transfer function (TF) of radionuclides from soil to cassava is 232 Th < 238 U < 40 K.

Amakom et al., (2015) examined cassava samples from an abandoned coal mining location in Enugu State, Nigeria, using gamma ray spectroscopy. The results revealed that the radionuclides 40K, 226Ra, and 232Th had high mean activity concentrations in the Pottery, Camp 1, and Camp 2 sites.The activity concentration ranged from 193.68 to 300.92 Bq/kg for 40 K, from 23.03 to 37.24 Bq/kg for 226 Ra, and from 135.33 to 158.43 Bq/kg for 232Th. The overall yearly effective dosage from these three radionuclides was calculated to be 2.03 mSv/yr, which is cause for concern. This figure exceeds the recommended limit of 1 mSv/yr, indicating that cassava intake in this region may pose health risks owing to radioactive pollution. In summary, the study discovered increased levels of radiotoxicity in cassava samples from the examined area, raising concerns about the safety of consuming cassava from

Alao et al., (2015) investigated the concentration of alpha and beta radioactivity in tubers and grains from selected oil fields in Nigeria's Niger Delta region. Samples of tubers and cereals were collected and evaluated for gross alpha and beta activity with an IN-20 gas-flow proportional counter. The average gross alpha and beta activity for tuber samples ranged from 0.294±0.0391 to 0.293±0.053 Bq/g, while cereal samples ranged from 0.087±0.040Bq/g to 0.414.±0.040 Bq/g.this region. The study found that gross alpha activity was higher than in control samples from non-oil-bearing environments and exceeded the World Health Organization standard limit of 0.1 Bq/g. However, average beta activity was below the WHO limit of 1.0 Bq/g in all zones studied. The elevation in the surveyed areas may be caused by oil exploration activities, including gas flares, pollutants, airborne transportation, oil spills, and accidental contamination of the food chain. However, the obtained results may not represent major health risks to consumers of these items.

(Chijioke et al., 2018), investigated the gross alpha and gross beta activity concentrations in cassava tuber samples cultivated near the former coal mine area in Enugu, the eastern part of Nigeria. In the mined region, the gross alpha activity concentration ranged from (BDL) to 0.670 Bq/g, whereas the gross beta activity concentration ranged from BDL to 1.220 Bq/g. The gross alpha and gross beta ranged from (BDL) to 0.590 Bq/g and 0.070 to 0.770 Bq/g, respectively, throughout the coal processing and distribution

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area. Gross beta activity concentration in the control region was observed to range from 0.370 to 1.420 Bq/g and gross alpha activity concentration from 0.020 to 0.690 Bq/g. Nonetheless, the study's findings indicate that the region's coal mining operations have had no impact on the levels of gross alpha and gross beta radiation in the cassava crops grown in the areas under consideration.

Barkin – Ladi Local Government in Plateau State is a mining area where Tin is mined and the Living Stone Potato (Plectranthus esculentus) is also grown and exported to other parts of the country. Some of the Living-stone Potatoes are grown near mining regions. Therefore, it is crucial to monitor the effects of these radionuclides on the agricultural output in the vicinity of mining zones. This clarifies the need for this study

- *Study Area*

The study area is Barkin Ladi Local Government Area in Plateau State, Nigeria. Longitude: 8° 53' 59.99" N. Latitude: 9° 31' 59.99" N. It includes the districts and communities of Barkin Ladi, Gashishi, Tafan, Zabot, Gassa & Sho, Gindi Akwati, Helpane, Kapwis, Lobiving, Marit, Mazat, and Kura Falls.

II. MATERIALS AND METHOD

- *Sample Preparation*

Four locations—01, 02, 03, 04, in Barkin Ladi were designated as study areas. Three different farms gave samples of living-stone potatoes at each location. The samples were sorted by location and thoroughly cleansed with clean water before being rinsed with distilled water to remove surface grit and other contaminants. A stainless-steel knife was then used to chop each tuber into 10mm^2 pieces, which were then spread out in four different trays according to location before drying at room temperature for around 10 days.

The samples were further oven dried at a constant temperature of 100^0 until a constant mass was obtained. The dry samples were mashed in a mortar and pestle before being passed through a 100-mesh sieve. The produced samples were pelletized into counting planchet size using a hydraulic compressor machine. All samples were meticulously prepared in accordance with International Atomic Energy Agency (United Nations Scientific Committee on the Effects of Atomic Radiation, 2010b) criteria for gross alpha and beta analysis before being stored in desiccators awaiting counting.

- *Sample Analysis*

The alpha and beta activity concentration of the prepared samples were determined using the low background Gas-less Alpha/Beta counting instrument (Protean Instrument Corporation (PIC) MPC 2000DP), which was calibrated using alpha (239Pu) and (90Sr) standards. The system employed a solid-state silicon detector for alpha and beta detection, known as a passivated implanted Planar Silicon, or PIPS. The gross alpha counting was counted for 3 cycles of 3600sec per cycle. Similarly, the gross beta counting was counted for 3 cycles of 3600sec in beta only mode. The efficiencies for alpha and beta were determined to be 87.95% and 42.06% respectively. The detection limits for alpha and beta were 0.21cpm and 0.22cpm, respectively, whereas the detector's background readings for alpha and beta activity concentrations were 0.50cpm and 0.73cpm. All measurements were conducted at Ahmadu Bello University's Low Background Laboratory, located at the Center for Energy Research and Training in Zaria, Nigeria.

III. RESULTS AND DISCUSSION

The findings are provided and discussed further below. Table 1 shows the locations and sample codes where the Living-stone Potatoes were collected. Table 2 displays the results of the activity concentrations of gross alpha and gross beta in the collected samples, together with their statistical errors (deviation), while Table 3 shows a summary of the results.

Table 1 The Living-Stone Potato Samples and their Location

S/No.	Sample Location	Sample Code	Description of the sample
1	Atoso	01	Mining area
2	Nafan numbers	02	Mining area
3	Reppiyam	03	Non mining area
4	Kuppang	04	Non mining area

Table 2 The Gross Alpha and Gross Beta Activity Measurement of Samples of Living-Stone Potato with their Statistical Errors

S/N	Sample code	Alpha activity Bq/g	Error	Beta activity Bq/g	Error
1	*01	$7.306x10^{-2}$	5.93×10^{-3}	$5.975 \times 10\ 10^{-2}$	1.93×10^{-3}
2	*02	$3.535 x10^{-2}$	1.42×10^{-3}	BDL	BDL
3	**03	$2.214 x10^{-2}$	9.44×10^{-3}	1.397×10^{-2}	1.98×10^{-3}
4	**04	1.964×10^{-2}	9.24×10^{-3}	$3.495\ \ 10^{-2}$	3.496×10^{-3}

*BDL is Below Detection Limit
*Mining area sources
**Non mining area sources

Table 3 The Summary of the above Result is Shown Below

S/No.	Sample Code	Alpha activity Bq/g	Beta activity Bq/g
1	01	0.07306± 0.00593	0.0598± 0.00193
2	02	0.03535 ± 0.00142	BDL
3	03	0.02214± 0.00944	0.01397± 0.00198
4	04	0.01964± 0.00924	0.03495 ±0.003496
	Average value	0.03754±0.006633	0.03624 ± 0.002469
	Minimum value	0.01964± 0.00924	BDL
	Maximum value	0.07306± 0.00593	0.0598± 0.00193

The mean activity of Living-stone potatoes collected from mining locations ranged from 0.07306 ± 0.00593Bq/g to 0.03535 ± 0.00142Bq/g, whereas samples from non-mining locations ranged from 0.01964± 0.00924Bq/g to 0.02214± 0.00944Bq/g. The mean activity values of the gross alpha activity concentration in tubers of Living-stone Potatoes in the mining region are higher than those in the non-mining area, although they are lower than the World Health Organization's recommended safe limit of 0.1Bq/g (World Health Organization, 2004)

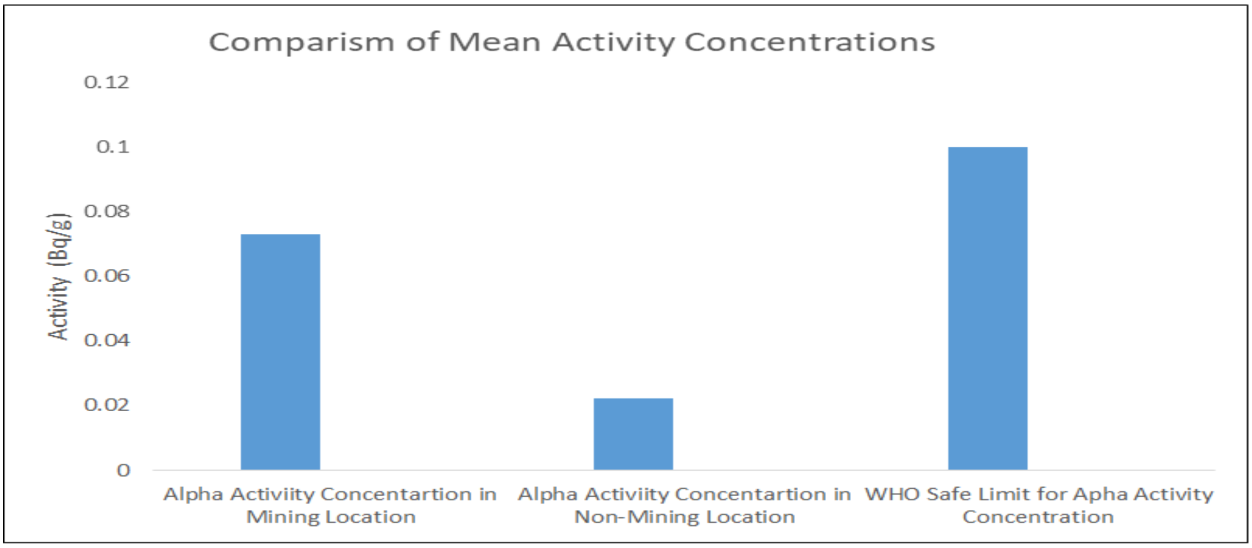

Fig 1 Comparism of Mean Activity Concentrations

The beta activity concentration in samples of Living-stone Potato tubers cultivated in the mininsg area ranged from BDL to 0.0598 ± 0.00193Bq/g. Samples from non-mining locations had values ranging from 0.01397± 0.00198Bq/g to 0.03495 ± 0.003496 Bq/g. The mean activity values of the gross beta activity concentration in tubers of Living-stone Potato in mining areas are likewise higher than those in non-mining areas, but they are lower than the (World Health Organization, 2004) recommended safe limit of 1.0Bq/g.

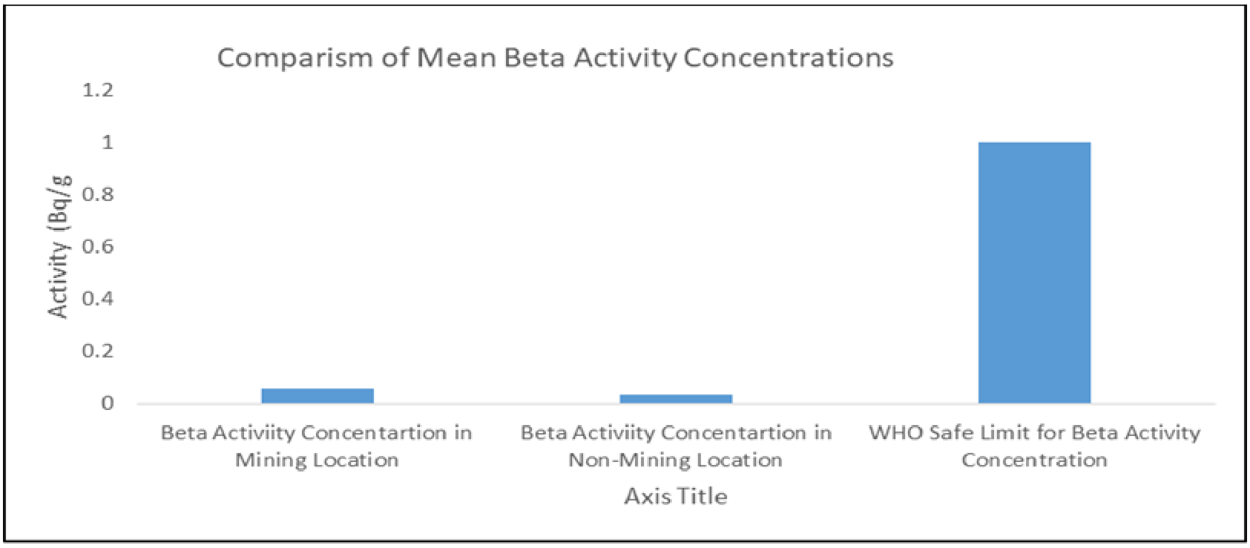

Fig 2 Comparism of Mean Beta Activity Concentrations

The results obtained in this study were much lower when compared to the mean gross alpha and beta activity concentration reported by Chijioke et al., (2018), who reported a mean rang of alpha activity concentration of BDL to 0.690 Bq/g and an average range of BDL to 1.420 Bq/g for beta activity concentration in cassava tubers in the old coal mining area in Enugu state, southern eastern Nigeria. The findings are consistent with those of our study in that there was no significant difference in alpha and beta concentrations in sample tubers collected from mining and non-mining areas. In a study by Alao et al., (2015), the average gross alpha concentration values obtained in this study are far lower than the average values obtained in tubers (BDL to 0.294±0.0391Bq/g) and cereals (BDL to 0.087±0.040 Bq/g) in selected oil fields in the Niger Delta Region of Nigeria. Additionally, the average gross beta concentration values obtained in this study are much lower than those reported in tubers (BDL to 0.293±0.053 Bq/g) and cereals (BDL to 0.414.±0.040 Bq/g) in the same study. The study also found an increase in alpha and beta concentrations in the oil exploration area compared to control samples, which is consistent with the findings of this study.

The results of our study indicate a significantly higher alpha and beta activity concentration than the combined values of 40K (0.01236 ± 0.00082Bq/g to 0.05692 ± 0.00884 Bq/g), 226Ra (0.00146 ±0.00005Bq/g to 0.01042 ± 0.00004 Bq/g), and 228Th (0.00153 ±0.00008Bq/g to 0.00685 0.00042 Bq/g) gamma activity concentrations in food crops on the Jos – Plateau as reported by Jwanbot, D.I et al., (2012). In comparison to their control samples, these values were found to be comparatively high, which is also in line with the trend of the results in our study The results of our study showed lower activity concentrations when compared to those reported by Irunkwor et al., (2022) for cassava tubers in the oil-producing state of Rivers. This is also consistent with previous findings (Alao et al., 2015; Chijioke et al., 2018), who ascribe the increase in activity concentration to mining and exploratory activities in the impacted regions. The present study's results were also found to be lower than the gamma activity concentrations recorded in the Radiological Analysis of Cassava Samples From a Coal Mining Area in Enugu State Nigeria by Amakom et al., (2023).

IV. CONCLUSION

The gross alpha and gross beta activity concentrations in living stone potatoes grown near mining and non-mining locations in the Barkin-Ladi local government area of plateau state have been determined. The results indicate that the activity concentrations in living stone potato samples cultivated in mining locations are higher than those in non-mining locations. The elevations are not especially high, but they indicate that mining activities in these areas have the potential to increase radiation doses in food crops grown near mining locations. Although the mean gross alpha activity concentration in Living-stone Potato tubers in the mining region are higher than those in the non-mining area, they are lower than the safe level of 0.1Bq/g suggested by (World Health Organization, 2004) . Likewise, the mean activity values of the gross beta activity concentration in Living-stone Potato tubers in the areas surveyed are also lower than the 1.0Bq/g safe level established by the (World Health Organization, 2004). The rise in alpha and beta activity that has been observed in mining areas may be associated with the quality of irrigation water, local human activities like mining around farms, and fertilizer use in farming. In a nutshell, all of the results obtained from the locations under the survey showed that the living stone potatoes grown in the surveyed area are safe for human consumption and do not now pose a radioactive risk to those who consume them.

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